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SELECTED MATERIAL FROM SOVIET TECHNICAL LITERATURE, OCTOVER 1972

Stuart G. Hibben

Informatics, Incorporated

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INTRODUCTION

This report includes abstracts and bibliographic lists on major contractual subjects that were completed in October, 1972. The major topics are: laser technology, effects of strong explosions, geosciences, and particle beams. Sections on material science and a biocybernetics bibliography have been included as the optional topics, as well as a section on items of miscellaneous interest.

To avoid duplication in reporting, only laser entries concerning high-power effects are routinely included, since all current laser material appears regularly in the quarterly bibliographies.

An index identifying source abbreviations and an author index to the abstracts are appended.

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13. ABSTRACT

This report includes abstracts and bibliographic lists on major contractual subjects that were completed in October, 1972. The major topics are: laser technology, effects of strong explosions, geosciences, and particle beams. Sections on material science and a biocybernetics bibliography have been included as the optional topics, as well as a section on items of miscellaneous interest.

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An index identifying source abbreviations and an author index to the abstracts are appended.

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1. Laser Technology

A. Abstracts

Zverev, G. M., Ye. A. Levchuk, V. A. Pashkov, and Yu. D. Poryadin. Surface damage in lithium niobate and tantalate from laser radiation. Kvantovaya elektronika, no. 8, 1972, 94-96.

This is a more detailed analysis of experiments recently described by the authors (April Monthly Report, p. 2) on laser damage thresholds of $LiNbO_3$ and $LiTaO_3$. An Nd glass laser was used in both free-running and single pulse modes to establish the threshold characteristic of wafer specimens with initially polished surfaces. In the single pulse regime the second harmonic (0.53μ) was also used, but this showed no significant change in damage threshold over the fundamental. As reported earlier, the point of emphasis is the anomalous cumulative effect of pulses on lowering the threshold, which distinguishes these materials from other transparent dielectrics such as ruby or glass. The comparative effect is seen in Fig. 1 for the two test materials.

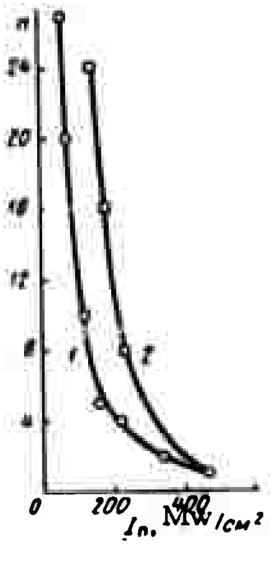


Fig. 1. Damage threshold in $LiNbO_3$ (1) and $LiTaO_3$ (2) vs. number of laser pulses

The authors cite numerous observed effects to indicate that nonlinear absorption does not play a part in the damage process here; for example, threshold was virtually independent of the level of surface polish in the target specimens. It was also noted that, beyond a certain focused spot size, threshold became independent of spot size, as seen in Fig. 2. The following mechanism is therefore proposed: for $LiNbO_3$,

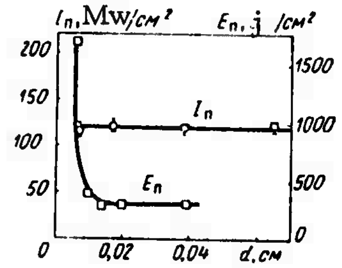


Fig. 2. Damage threshold in $LiNbO_3$ vs. beam diameter

existing concentrations of Nb^{5+} ions on the surface cause a preferential surface heating under the laser pulse leading to Nb^{4+} formation and a further surface absorption; this process is cumulative under repeated pulsing until threshold is reached by local heating. The same would hold for the $Ta^{5+} \rightarrow Ta^{4+}$ reaction, although this requires a higher temperature (600-700° C), which would explain the higher threshold characteristic of $LiTaO_3$ in Fig. 1. The authors also note that the natural piezoelectric properties of $LiNbO_3$ may be a factor in its damage threshold, owing to a surface charge layer, and propose further tests along this line. Sample damage photos are given in Fig. 3.

Fig. 3. Surface damage to laser-irradiated $LiNbO_3$. a- single-pulse regime, after 6--8 pulses at threshold (x 300); b- after 20--30 pulses (x300); c- after free-running exposure (x 150)

Popov, S. P. Stationary regime of the radially-symmetrical motion of laser heated vapors, taking temperature and ionization nonuniformity into account. ZhPMT, no. 4, 1972, 3-7.

This is a theoretical study concerning the effect of temperature and ionization nonequilibrium on the motion of vapor products generated by laser interaction with a solid surface. The case is considered for stationary motion of a radially symmetrical vapor cloud, generated by power densities $q = 5\text{-}20$ Mw/cm^2 and focused radius $r_o = 0.01\text{-}1$ cm. In an earlier paper on this problem, Nemchinov (PMM, v. 3, no. 2, 1967, 300-319) considered the coefficient of beam absorption to be constant or to vary according to a power law as a function of temperature and density. The conditions for a stationary regime were then established in terms of vaporized mass, surface pressure, maximum vapor temperature, and vapor cloud radius.

Popov extends this treatment to account for a more realistic behavior of absorption coefficient as a function of temperature and density, referring to a stationary regime at $T = 20,000^oK$ and $q = 100$ Mw/cm^2, i.e. in the range where transition from the nonshielding to the shielding situation occurs. Nemchinov and Popov have previously analyzed the effect of temperature nonequilibrium on plasma heating in this model, showing that it acted to reduce the critical flux q_o at which shielding begins. (February 1972 Report, p. 5). Popov shows that an analogous situation applies to the stationary mode; in fact, for the assumed parameters of the cited beam-target model, q_o drops by a factor of 2-2.5 when thermal nonequilibrium is taken into account. Graphical solutions are given comparing transition region characteristics for the two cases.

Sultanov, M. A. Razrusheniye nekotorykh prozrachnykh dielektrikov pod deystviyem neodimovogo i rubinovogo lazerov v rezhime svobodnoy generatsii. (Damage in various transparent dielectrics from free-running ruby and neodymium lasers). Fiz-tekhn. institut AN TadzhSSR. Dushanbe, 1970, 19p. (RZhF, 5/72, no. 5D1093)

It is shown that a powerful laser beam interacting with various polymer materials will generate a hydrodynamic explosion process, which is accompanied by a shock wave and plasma formation in the material. The destruction mechanism in transparent dielectrics is postulated in the beam focal region as well as behind it.

Adam, A., D. Horvath, P. Hrasko, Zs. Kajcsos, and M. Labadi. Positron annihilation in a laser radiation field. Kozp. fiz. kut. intez. no. 72, 1971. (RZhF, 5/72, no. 50196) (Translation)

Positron annihilation in NaCL crystal was observed in the presence of a laser field. It was established from time spectral analysis that the decay constant of long-lived components was approximately 20% greater under laser radiation than without it.

Mitsuk, V. E., R. M. Savvina, and V. A. Chornikov. Optical breakdown in gas mixtures. 10th Int'l Conference on Phenomena of Ionized Gases, Oxford, 1971, 233. (RZhMekh, 8/72, no. 8B201)(Translation)

Studies were made on lowering the breakdown threshold of gas mixtures irradiated by a Q-switched Nd glass laser. The mixtures tested were Hg + Ar, Hg + Kr, Hg + He, He + Ar, He + Kr and He + Xe. Test results with all mixtures agreed well with the theory of simple avalanche ionization of gas by electrons, and indicated that atom-atom collisions are not a significant factor in the breakdown process.

Osadin, B. A., and G. I. Shapovalov. Pulsed vaporization in a vacuum. TVT, no. 2, 1972, 361-367.

Works on the effects of laser radiation on substances in a condensed state by Anisimov, et al. (Nauka, 1970) and Afanas'yev and Krokhin (IN: Trudy FIAN, v. 52, 1970, 118), which considered evaporation under the influence of high-intensity heat fluxes, have as a rule examined the quasi-steady stage of the process, characterized by a constant velocity of the evaporation wave moving into the substance. The present paper deals with the non-steady stage of the process at moderate heat fluxes ($Q = 10^5 - 10^8$ w/cm^2) which, besides lasers, can also be created by electron beams in an electric discharge.

A computer-aided solution of the equation of thermal conductivity was obtained for aluminum, copper, and titanium. Consideration was given to evaporation from the surface into a vacuum at heat fluxes of $10^5 - 10^8$ w/cm^2 to the surface. The time relationships of the process of pulsed evaporation in a vacuum are discussed, as well as the application of the obtained solution.

Bonch-Bruyevich, A. M., Ye. N. Kaliteyevskaya, and T. K. Razumova. Effect of single-pulse ruby laser radiation on a mercury arc plasma. OiS, v. 32, no. 6, 1972, 1171-1175.

It was determined by the authors that, when the radiation of a single-pulse ruby laser is focused into the region of a direct-current arc discharge, the discharge radiation flux increases and the voltage at the discharge gap drops. A superhigh-pressure mercury lamp was used in the investigation; the interelectrode gap was 1.4 mm; the incandescent body diameter was 0.9 mm; current was 6.3 a; and the discharge gap voltage was 43 v. The voltage drop is linked both to photoionization and, more significantly, to electron heating by laser radiation. Assuming that the electron concentration value is linearly related to the decreasing laser radiation, an increase of the lam flux radiation in the background region proportional to the square of the number of electrons will have a square-law relationship to the laser energy. The line flux increment is apparently linked to a population density increase of the corresponding states of HgI. The increase is also probably related to population due to recombination during triple collision, stepwise electron impact excitation and cascade transitions from the higher excited states populatec during ion recombination. An evaluation of the energy balance in the excited plasma shows that the energy consumption for additional ionization and excitation, heating the initial electrons and the new electrons and ions, and for radiation comprised about 30% of the absorbed energy. This evaluation was made under the assumption that the plasma was heated from 8000 to 8600 K, the number of electrons was increased by 75%, and the radiation flux was increased by 100%.

Zaritskiy, A. R., S. D. Zakharov, P. G. Kryukov, Yu. A. Matveyets, and A. I. Fedosimov. <u>Variation in the back-scatter radiation spectrum from laser heating of a plasma</u>. ZhETF P, v. 15, no. 4, 1972, 184-188.

$(CH_2)_n$, $(CO_2)_n$, D_2O ice, and Al were used as targets in spectrum measurements of laser beams reflected from plasma. The emission source was a mode-locked neodymium glass laser comprising a generator and a six-stage amplifier. The spectral measurements and the plasma heating were carried out on a fundamental frequency $\lambda = 1.06\mu$ as well as the second harmonic $\lambda = 0.53\mu$. Harmonic conversion was effected at an efficiency of up to 50% by a KDP crystal. The initial oscillation spectrum was contracted to ~ 0.05 Å by inserting Fabry-Perot axial mode selectors into the resonator. The laser pulse was thereby lengthened to 1 nsec.

Spectrograms for four laser bursts on a LiD target (objective f = 4.5 cm, $\lambda = 0.53\mu$) show that a large number of equidistant lines can be seen in the light spectra reflected from the plasma. The lines generally are situated both in the Stokes and the anti-Stokes portions of the spectra. The number of lines is a function of the energy and, as a rule, the greater the burst energy the greater the number of lines. The width of each line is within the resolution limits of the equipment (0.05 Å). At an output-energy level of about 5 j, spectra were recorded with variable focusing: objective f = 4.5 cm and lens f = 30 cm. In the first case line multiplication was continuous, while in the second case it was observed in about half of the bursts; this reflects the threshold character of the effect, since the focal spot diameter was one order greater for the lens.

Supplementary measurements show that the equidistant lines in the reflected-emission spectra are linked to the presence at the incident-emission line of weaker companion lines (at least one hundred times less intense). The distance between the companion lines is equal to the interval between the lines of reflected light. These lines were found to be due to the selection in the generator modes of exceptionally weak interferometer optical element parasitic reflections.

Kochelap, V. A. Negative absorption of light in a dense ionized gas. ZhTF, no. 2, 1972, 449-451.

The theoretical possibility is explored of achieving negative absorption in a non-equilibrium dense ionized gas through electron radiative capture by neutral atoms which exhibit affinity for the electrons (negative ion continuum). The gain factor formula

$$\alpha(\omega) = \sigma_\omega \left[\frac{g_i}{2g_a} \left(\frac{2\pi\hbar^2}{m_e k T_e} \right)^{3/2} e^{-\frac{\hbar\omega - \epsilon_c}{kT_e}} n_a n_e - n_i \right]. \quad (1)$$

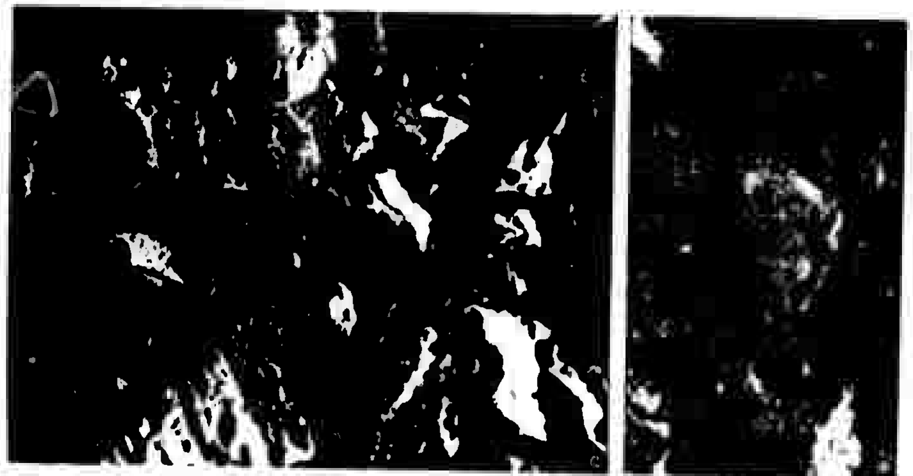
(where ω is the cross-section of electron photodetachment from the negative ion, g_a and g_i are multiplicities of degenerate atoms and ions; m_e is the electron mass; ϵ_c is the atom affinity; and n_a, n_e, and n_i are concentrations of atoms, electrons, and negative ions, respectively) was derived from consideration of thermodynamics. This formula shows that a gain in the negative ion continuum can be achieved, if n_i is maintained below its equilibrium value. An evaluation of α was made for a nonequilibrium H plasma with $T_e = 5{,}000^\circ$ K using the formula and the assumption that $n_i \longrightarrow 0$. It was shown that a significant gain can be achieved under these conditions; e.g., at the frequency $\omega = 2.10^{15}$ sec^{-1} and the degree of ionization $x = 0.5$, α attains a maximum value of $0.3\ cm^{-1}$. A predominance of photostimulated over spontaneous emission from a nonequilibrium ionized gas interacting with a powerful light wave is shown

to occur at a photon optical density $q > q_m$. The threshold q for H under the cited conditions is $q_m = 2 \times 10^{13}\ cm^{-3}$. A theoretical high quantum yield can be obtained in the system studied. The low n_i values necessary for realization of negative absorption in nonequilibrium plasma presumably may be attained by cooling the electrons to T_a in a time τ_e significantly shorter than the times of electron capture by neutral atoms and the electron recombination with positive ions. A nonequilibrium plasma with the required parameters can also be created by directing an $n_e \geq 10^{16}\ cm^{-3}$ electron beam into a gas.

Poplavskiy, A. A., G. P. Tikhomirov, and T. S. Turovskaya. Electron microscope examination of radiation damage in dielectrics. ZhTF, no. 7, 1972, 1462-1463.

A brief description is given of laser radiation damage to glass and a combination of ZnS plus MgF_2 on a glass substrate. In all cases the beam intensity was below visual damage threshold, ranging from low levels up to 85% of critical. Fig. 1 gives a magnified view of laser effect on polished type K-8 optical glass, showing the increasing fusion effect as threshold is approached. The overall damaged region was noted to be considerably greater than laser beam area.

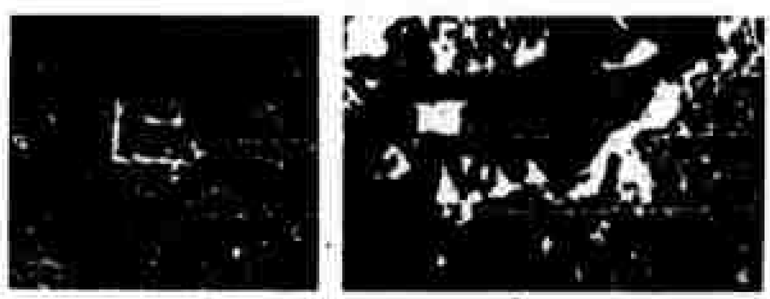
(See Fig. 1 on next page)



a b

Fig. 1. Subthreshold damage to glass. Fused region in (b) is 6μ in diameter.

In contrast, the layered dielectric coating showed damage beginning at a much lower energy density. Fig. 2 shows cavities on the



a b

Fig. 2. Subthreshold damage to $ZnS+MgF_2$ on glass, a- at 0.4 Q_{thr}; b- at 0.85Q_{thr}

order of 2μ appearing at 0.4Q_{thr}. The tests thus verified that the damage effect in the two cases was different at low laser energies but becomes qualitatively the same as threshold is approached. The damage patterns suggest that energy is absorbed in a subsurface layer, in accordance with the results of Bonch-Bruyevich et al on optical glass (cf Effects of High Power Lasers, Dec. 1971, 52)

B. Recent Selections

i. Beam Target Effects

Baranov, M. S., V. A. Kondrat'yev, and A. A. Uglov. Kinetics of wire joint formation from pulsed laser beam welding. FiKhOM, no. 5, 1972, 11-14.

Bayramov, B. Kh., B. P. Zakharchenya, and Z. M. Khashkhozhev. Self-focusing of argon laser radiation in $Bi_{12}SiO_{20}$ crystals. FTT, no. 9, 1972, 2730-2736.

Danileyko, Yu. K., A. A. Manenkov, V. S. Nechitaylo, A. M. Prokhorov, and V. Ya. Khaimov-Mal'kov. Role of absorbing inclusions in the destruction of transparent dielectrics by laser radiation. ZhETF, v. 63, no. 3, 1972, 1030-1035.

Gerasimov, B. P. Effect of laser beam scattering and absorption on strong shock wave structure. IN: Trudy Konferentsii Moskovskogo fiz.-tekhnicheskogo instituta, 1970. Seriya Aerofizicheskaya. Prikladnaya matematika, Moskva, 1971, 14-24. (RZhF, 9/72, no. 9D934)

Gryaznov, I. M., A. A. Kovalev, L. I. Mirkin, and P. I. Ulyakov. Study of melt zone and thermal effect in metals from laser beams of varying duration. FiKhOM, no. 5, 1972, 8-10.

Stoyanova, I. G., A. A. Timofeyev, A. V. Antipova, G. G. Levadnyy, and A. N. Zelyanina. Electron microscopic analysis of pore formation in thin resistive films from coherent radiation. IAN Fiz, no. 9, 1972, 1936-1944.

Volosevich, P. P., and Ye. I. Levanov. Self-similar motion in a dual-temperature plasma. IN: Sbornik. Teplo- i massoperenos, Minsk, v. 8, 1972, 29-35. (RZhF, 8/72, no. 8G184)

Volosov, V. D., A. M. Dukhovnyy, V. N. Krylov, and T. V. Sokolova. Laser beam second harmonic conversion in a free generation regime. Kvantovaya elektronika, no. 2(8), 1972, 101-102.

ii. Beam-Plasma Interaction

Batanov, V. A., F. V. Bunkin, A. M. Prokhorov, and V. B. Fedorov. Self-focusing of light in a plasma and a supersonic ionization wave in the laser beam. ZhETF P, v. 16, no. 7, 1972, 378-382.

Demidov, B. A., S. D. Fanchenko, G. V. Sholin, S. D. Zakharov, and P. G. Kryukov. Plasma heating by very short laser pulses. Phys. Lett., v. A38, no. 5, 1972, 303-304. (RZhF, 7/72, no. 7G687)

Kaliski, S. Alternative description of laser plasma heating, taking ener of synthesis of spherical thermal waves into account. Biul. WAT J. Dabrowskiego, v. 21, no. 2, 1972, 3-9. (RZhF, 7/72, no. 7G533)

Kaliski, S. Alternative description of laser heating of dual-temperature plasma due to thermal conductivity, taking energy of synthesis of spherical symmetry into account. Biul. WAT J. Dabrowskiego, v. 21, no. 2, 1972, 19-26. (RZhF, 7/72, no. 7G534)

Kaliski, S. Cumulation-magnetic laser heating of a D-T plasma and energy output due to thermonuclear reactions. IN: Proc. Vibrat. Probl. Pol. Acad. Sci., v. 12, no. 4, 1971, 377-389. (RZhF, 7/72, no. 7G720)

Kaliski, S. Laser heating of dual-temperature plasma due to thermal conductivity, taking energy of synthesis of spherical symmetry into account. Biul WAT J. Dabrowskiego, v. 21., no. 1, 1972, 25-30. (RZhF, 7/72, no. 7G538)

Kaliski, S. Laser heating of dual-temperature plasma due to thermal conductivity, taking energy of synthesis of the nucleus into account. Biul. WAT J. Dabrowskiego, v. 21, no. 1, 1972, 3-9. (RZhF, 7/72, no. 7G539)

Kaliski, S. Laser plasma heating in the case of a spherical thermal wave, taking the energy of synthesis of nuclear reactions into account, Part 1. IN: Proc. Vibrat. Probl. Pol. Acad. Sci., v. 12, no. 4, 1971, 349-357. (RZhF, 7/72, no. 7G541)

Kaliski, S. Laser plasma heating in the case of a spherical thermal wave, taking the energy of synthesis of nuclear reactions into account, II IN: Proc. Vibrat. Probl. Pol. Acad. Sci., v. 12, no. 4, 1971, 359-362. (RZhF, 7/72, no. 7G540)

Kaliski, S. Averaged equations of simultaneous hydrodynamic expansion and thermal heating of plasma, taking energy distribution of nuclear synthesis into account. Part 1, planar symmetry. Biul. WAT J. Dabrowskiego, v. 21, no. 2, 1972, 39-46. (RZhF, 7/72, no. 7G542)

Kaliski, S. Averaged equations of simultaneous hydrodynamic expansion and thermal heating of plasma, taking energy release of nuclear synthesis into account. Part 2, spherical symmetry. Biul. WAT J. Dabrowskiego v. 21, no. 2, 1972, 47-52. (RZhF, 7/72, no. 7G543)

Kopvillem, U. Kh., V. R. Nagibarov, Z. M. Kaveyeva, V. A. Pirozhkov, V. V. Samartsev, and R. G. Usmanov. Laser pulse deformation in resonant media. UFZh, no. 9, 1972, 1557-1558.

Kronast, B., and R. Benesch. Observation of line structure in light scattering spectrum of electron plasma waves in a magnetized plasma. IN: 10th International Conference on Phenomena of Ionized Gases, Oxford, 1971, 415. (RZhF, 7/72, no. 7G713)

Letokhov, V. S. Narrow resonance emission and absorption of gamma-ray nuclear radiation stimulated by lasers. ZhETF P, v. 16, no. 7, 1972, 428-431.

Tyurin, Ye. L., and V. A. Shcheglov. Radiant heat wave in a moving plasma. ZhTF, no. 8, 1972, 1586-1590.

Vinogradov, A. V., and V. V. Pustovalov. Indutsirovannoye rasseyaniye sveta na chastitsakh plazmy i yeye nagrev moshchnymi lazernymi puchkami. Uchet dinam. polyarizatsii plazmy (Stimulated light scattering on plasma particles and heating by powerful laser beams. Calculation of plasma polarization dynamics). AN SSSR, Fizicheskiy institut imeni P. N. Lebedeva, Preprint no. 135, Moskva, 1971, 85 p. (KL Dop vyp, 5/72, no. 9705)

2. Effects of Strong Explosions

A. Abstracts

Aleksandrov, V. V., and V. N. Koterov. Classification of shock waves in a radiating gas. ZhVMMF, no. 3, 1972, 700-713.

All possible shock wave types in a radiating gas were studied theoretically on the basis of the differential equation in the phase plane, i.e. in a gas velocity v-radiation density W coordinate system rather than in the standard v-optical thickness τ system. The phase plane system introduced by one of the authors (MZhiG, no. 1, 1972, 144-155) simplifies calculations, assuming that the radiative energy transfer is described in a diffusion approximation of radiation intensity. Presumably, a plane stationary shock wave propagates in a gray, inviscid, thermally nonconductive perfect gas, simultaneously radiating, absorbing, and scattering. The earlier established basic equations are solved by plotting two integral curves originating in the (v_1, θ_1^4) and (v_2, θ_2^4) singular points in the v-w plane and by determining the gas velocities $v- = v(-0)$ and $v+ = v(+0)$ at the discontinuity boundaries. The assumption of a thermodynamic equilibrium at $|\tau| = \infty$ led to the boundary conditions

$$w(v_1) = \theta^4(v_1) = \theta_1^4, \quad w(v_2) = \theta^4(v_2) = \theta_2^4. \tag{1}$$

where θ_1^4, θ_2^4 are the singular point temperatures. The earlier established discontinuity condition led to the conclusion that the v profile is continuous only at $w(v_s) = \theta^4(v_s) = \theta_s^4$, where v_s is the velocity in an isentropic sonic plane. The (v_s, θ_s^4) point is the third singular point of the w(v) integral curves. Analysis of the basic dw/dv equation and its solutions for singular

points made it possible to distinguish three types of shock waves: weak (1), and strong with pre-critical (2), or supercritical (3) amplitudes. The shock waves are considered weak when the gas propagates through the wave at an isothermally supersonic velocity $v_2 > v_T$ ($v_T = 1/2$ is the velocity in an isothermal sonic plane). The strong waves, at $v_2 < v_T$, are of pre-critical or supercritical amplitude, when either v is totally dispersed at a sufficiently strong radiation effect or v is only partly dispersed at any radiation effect. A weak wave can be either partly or totally dispersed, depending on whether the effect of radiation on gas flow is moderate or strong. Conditions for the existence of the cited wave types are formulated in terms of the independent parameters γ, M_1^2, and b (b is the radiation effect parameter). The w(v), v(τ), and $\theta(\tau)$ curves are plotted for each wave type. Three asymptotic expansions of the basic differential equation describe the structure of the cited wave types in the presence of a strong radiation effect ($b \leq 1$).

Blitshteyn, Yu. M., S. I. Meshkov, and A. V. Chigarev. Wave propagation in a linear visco-elastic heterogeneous medium. MTT, no. 3, 1972, 40-47.

A theory of wave propagation in real media (polycrystals, composite materials, rock) is developed on the basis of a viscoelastic medium rheological model. The model is described by

$$\sigma_{ij} = \lambda e_{kk}\delta_{ij} + 2\mu e_{ij} \tag{1}$$

where λ and μ are linear integral operators whose kernels are continuous functions of space coordinates. The stress (σ_{ij}) and strain (e_{ij}) components

in (1) are expressed by a Cauchy formula and the equation of motion for a continuous medium whose density ρ is a continuous function of space coordinates. Since the viscoelastic coefficients of heterogeneous materials are discontinuous functions, shock and acceleration wave propagation in such materials is described by the equations of discontinuity. The equations of wave surface motion and amplitude along a trajectory σ normal to the surface of a heterogeneous medium are derived from (1) with allowance for a Cauchy convergence test and the effects of wave reflection and refraction.

Formula (1) and the convergence test indicate that two kinds of shock or acceleration waves (longitudinal and transverse) exist in a heterogeneous medium. The propagation velecities $A^{(p)}$ and $A^{(t)}$ of the longitudinal and transverse waves obey the laws of linear heterogeneous elasticity

$$A = \rho c^2, \quad A^{(p)} = \lambda + 2\mu, \quad A^{(t)} = \mu \qquad (2),$$

where C is the propagation velocity normal to the surface. The acceleration wave amplitudes $L^{(p)}$ and $L^{(t)}$ satisfy the equations of the shock wave amplitudes $S^{(p)}$ and $S^{(t)}$. The waves with removable and nonremovable discontinuities therefore propagate according to the same laws in heterogeneous as well as homogeneous viscoelastic media. Solutions of the S equations for a plane wave propagating in an oscillating viscoelastic medium reveal that S may be periodic or aperiodic. For a stochastically heterogeneous medium, the velocities $A^{(p)}$ and $A^{(t)}$ in (2) are random functions, and their distribution is stationary when the simultaneous distribution of density and elastic coefficients is also stationary. For small fluctuations of density and elastic coefficients, the solution of the $ds/d\sigma$ equation for S in a second approximation and the derived formula for the S correlation function in a first approximation indicate that the random distribution of S fluctuations is nonstationary, even for plane waves. In the general case, the dispersion of S fluctuations decreases along the ray σ.

Fortov, V. Ye. Acoustic radiation from a shock wave front in cesium vapors. ZhTF, no. 2, 1972, 333-335.

The instability of shock discontinuity, which creates regions of spontaneous acoustic radiation on shock adiabats is calculated. According to an earlier developed mathematical criterion for the existence of this instability, there must be a sharp right inflection $(dv/dP)_I$ of the shock adiabats in the P-V plane. The inflection may be caused by ionization and electronic excitation of gas heated by a shock wave. Calculations of cesium vapor shock adiabats indicate that the instability criterion is satisfied for certain shock wave parameters. The lower and upper bourdaries of the hydrodynamic instability region were calculated (Fig. 1).

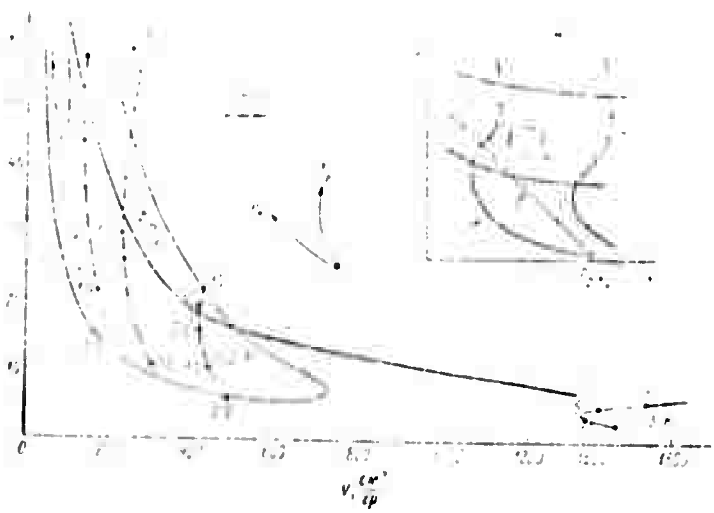


Fig. 1. P-V diagram of cesium plasma

1- curves of constant deviation from the ideal state $\Gamma = e^2/kT\rho D$ = const; 2- shock adiabats corresponding to a temperature T_k (in ^oK next to the curve), states ahead of the front are on the cesium saturation curve, He pressure P_k (in hundreds of atm) in the high-pressure chamber is shown along the adiabats; 3- instability boundary; A- schematic diagram of shock adiabats; the shaded area is the region of instability, R- the Rayleigh line $(P-P_0)/(V_0-V)$= const.

The calculated lower boundary is within the capability of the experimental realization of the instability type studied. In view of the possibility of observing acoustic radiation in a cesium pneumatic shock tube, He pressures and shock adiabats are given for use in selection of the shock discontinuity parameters. The realization of the upper boundary of the spontaneous acoustic radiation region is beyond the capability of even electric discharge shock tubes. It is suggested that acoustic radiation may cause frontal deformation or lamination of the shock compressed plasma, with effects which may be recorded by a pulsed x-ray technique.

Berezin, Yu. A., and G. I. Dudnikova. <u>Thermal conductivity effect on the structure and critical parameters of shock waves in plasma</u>. ZhPMTF, no. 2, 1972, 8-14.

The structures of standing and unsteady shock waves in a cold rarefied magnetoplasma are analyzed with and without allowance for finite (σ) and electron thermal conductivity (χ). The wave structure in the presence of σ and χ is described by differential equations of motion and energy. The problem of the standing wave structure is solved by first reducing the initial equations to two common equations in a coordinate system associated with the wave, and then reducing these to a single equation

$$M_*^2 + p_0 - \frac{1}{2}(H_*^2 - 1) - \frac{2M_*^2}{H_*} = 0 \qquad (1).$$

Using (1) and Hugoniot conditions for the singular point of the two common equations, the shock wave critical parameters M_* and H_* are calculated, assuming that the p_o ahead of the wave is ≤ 1. The numerical solution of

the standing wave problem in the presence of σ and χ shows that the shock wave profile is monotonic at $H_1 < H_* = 3$ and $M < M_* = 3.46$ and discontinuous at $H_1 > 3$ and $M > 3.46$. The M_* and H_* are ≈ 2.76 and ≈ 2.66 when χ is disregarded. The particle density profile $\Delta\rho$ decreases faster than the magnetic field profile Δ_H, when M is increased to 3.44, and $\Delta\rho$ tends to become discontinuous. At Δ_H = const., $\Delta\rho$ increases with an increase in χ.

To solve the unsteady wave problem, initial and boundary conditions are added to the initial set of equations in Lagrangian coordinates. Numerical solutions are presented graphically for three ranges of M. The shock wave is quasistationary at M<2.5 and a magnetic field amplitude of A = 1.5-2 at the plasma boundary. The shock wave quasistationarity is deduced from the presence of the piston-to-wave front transitional region of the typical H and N profiles (region 2, Fig. 1).

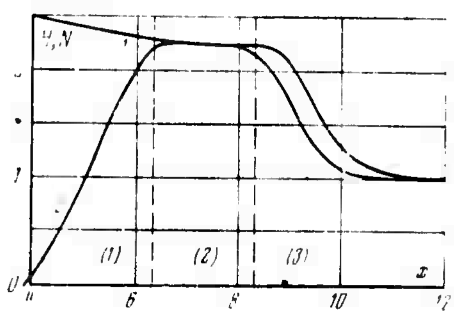


Fig. 1. Typical profiles of magnetic field H (curve 1) and particle density N (curve 2) in a shock wave with A = 1.5, $\beta = K\chi = 2$, and $M \approx 2.2$.

Numerical solutions at M<2.5 for $\chi \neq 0$ and $\chi = 0$ indicate, in agreement with the stationary solution, that the shock wave front expands negligibly in the presence of χ. At M in the 2.8 - 3.3 range, A = 2.7-4, and H = 2.9-3.0, a quasistationary isomagnetic density jump in the presence of χ occurs (Fig. 2).

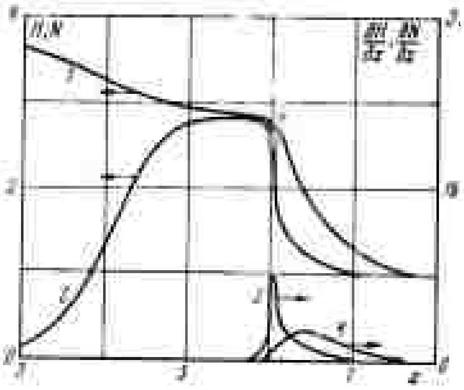


Fig. 2. Typical H (1), N (2), dN/dx (3), and dH/dx profiles in the wave front at A = 2.7, β = 2 and M$\approx$3.1

At A>4, shock wave H and V increase steadily leading to the breakdown of the isomagnetic shock. The breakdown occurs when $M_* > 3.4$, A = 5-8, and $H_* = 3\text{-}3.2$. The acousto-ionic wave velocity simultaneously becomes equal to the particle velocity behind the shock wavefront.

Lomakin, B. N., and V. Ye. Fortov. Pulsed x-raying of shock waves in dense cesium vapors. TVT, no. 6, 1971, 1291-1293.

A nonideal plasma was diagnosed using pulsed x-rays to determine the density N of cesium plasma generated in a shock tube. A pulsed regime was selected to produce high-intensity x-rays to maximize the sensitivity S of the experimental instrument and minimize the statistical error. A standard BSV-9 x-ray tube with a tungsten anode was used at a 1.5a peak current. Computation of S under the given conditions indicates that a

maximum S of N determination in the $(5.10^{18} - 10^{20})\ cm^{-3}$ range can be achieved by selecting an appropriate value of voltage across the tube within the 25-55 kv range for each N. Due to the high operating temperature (~600°C) the radiation detector and x-ray tube were located at a considerabe distance from the shock tube, which necessitated the use of special adjusting devices. The apparatus was calibrated against Xe. The oscilloscope traces of x-ray absorption in the Cs plasma behind the oncoming shock wave show the presence of a vapor lock behind the wave front. This produces a reflected shock wave which is important for diagnostics of strongly nonideal plasma regions. Tabulated experimental $N = N_a+N_i$ data for an Xe and Cs weakly nonideal plasma (behind a shock wave front) differ by ~5% from the theoretical $N_a + N_i$ data. The data obtained for the strongly nonideal plasma region will be published subsequently.

Zhmayeva, Ye. A., and A. I. Kharitonov. <u>Formation of a bow shock around blunt bodies in shock tubes.</u> MZhiG, no. 6, 1971, 131-136.

The interaction of a supersonic shock wave with blunt bodies was studied in a shock tube to examine the bow shock detachment in a non-steady flow. A single diaphragm shock tube was used with L/D = 280, where L is the diaphragm - to - model distance. The tube initial air pressure was 9-80 torr and the shock wave-front velocity u_1 was 850-1500 m/sec. A sphere, cylindrical models with variable blunt nose curvature radii, and a blunted cone model were tested. The coordinates and the bow shock shape were determined from interference patterns recorded by a Mach-Zender interferometer using a pulsed ruby laser source. The bow shock propagation path was defined more accurately, and the uniformity and duration of oncoming flow were determined from photographs of time sweeps. The measured bow shock detachment δ, accurate to 0.005-0.007, varied with time t according to similar patterns for all models and flows studied (M_1 of the wave front = 2.57-4.4) and remained practically unchanged after reaching a steady value δ_∞.

The shock detachment profile and velocity were formulated as approximate functions

$$\delta = (u_2/2V_0t + 1/\delta_1 - u_2/2V_0t_1)^{-1}, \qquad V = [1 + (2V_0/u_2\delta_1 - 1/t_1)t]^{-2} \tag{1}$$

of a given experimental δ_1 value at a time t_1, V_o=V at t=0, and u_2 flow velocity behind the shock front. The (1) plots describe with a sufficient accuracy the experimental time dependence of δ for all bodies studied at the cited M_1. The formulas

$$\delta = (u_2/2V_0t + 1/\delta_\infty)^{-1}, \qquad V = (1 + 2V_0t/\delta_\infty u_2)^{-2} \tag{2}$$

were also derived and give δ_∞ and V as functions of the experimental δ_∞. At small M_1, the δ values calculated from (2) and the experimental δ_∞ are more accurate than δ values calculated from (2), using theoretical δ_∞ calculated by the Ambrosio-Wortman formula. Times t_∞ at which δ = 0.8 δ_∞ (steady flow) were calculated using experimental δ_∞ for bodies with different r. It was shown that t_∞ increases with increase in r/R from 0.5 to 1.5, and decreases for the same body with an increase in M_1.

Gaponov, S. A., and A. A. Maslov. <u>Numerical solution to problem of full stabilization of a supersonic boundary layer.</u> ZhPMTF, no. 2, 1972, 39-43.

A numerical solution to the problem of full stabilization of a supersonic boundary is introduced, with no limitation on the parameter ϵ of asymptotic expansion which in previous studies was assumed to be small. This assumption, valid at M<2, might produce erroneous data at higher M,

because $\epsilon = (\alpha R)^{-1/2}$ is larger at M = 2-6 (α = perturbation wave number, R = Reynolds number). Full stability of a supersonic laminar boundary layer is defined as the critical surface temperature T_w^* at which the instability region in the T_w-αR plane disappears. Full stability is consequently represented by the curve of asymptotic αR values. This curve was calculated for M = 1.4-3.2 using the set of equations developed by Dun and Lin [J. Aeronaut. Sci., v. 22, no. 7, 1955]. The αR - T_w plots at M = 1.4 and 2.2 revealed the existence of two neutral stability curve branches at a significantly low T_w. The two branches merge into one curve at T_w^*. Velocity, temperature, and density distribution in the main flow were calculated by numerical integration of the equation of laminar boundary layer past a flat plate and the set of equations

$$z_{iy} = \sum_{j=1}^{6} G_{ij} z_j, \qquad (i = 1, \dots, 6) \tag{1}$$

with boundary conditions

$$z_1(0) = z_3(0) = z_5(0) = 0 \tag{2}.$$

Equations (1) were derived by introducing Z_1-Z_6 variables into the Dun and Lin equations. The lower branch of the neutral stability curve was plotted in α-R coordinates for M = 2.2 and T_w = 1.82. The effect of M on T_w is shown in Fig. 1.

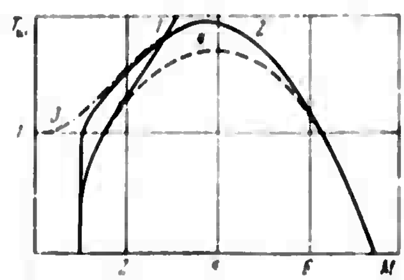


Fig. 1. Temperature T_w of full stability versus M: 1 and 2 - the first and second neutral curves calculated by the authors; 3- full inviscid stability curve; 4- curve calculated by asymptotic method of Dun and Lin.

At $M>2$, the authors' data also differ qualitatively from that calculated by the asymptotic method. This discrepancy is particularly evident at $M>2.7$, presumably because of the growing effect of temperature perturbations on velocity perturbations.

Lerman, M. I. Hypersonic flow around a body of revolution subjected to fan jet blowing. VLU, no. 7, 1972, 96-101.

A theoretical analysis is presented of hypersonic flow over an unyawed body of revolution with injection of a supersonic gas jet normal to the external flow. The fan jet is injected through a radial ring nozzle in the body surface (Fig. 1a).

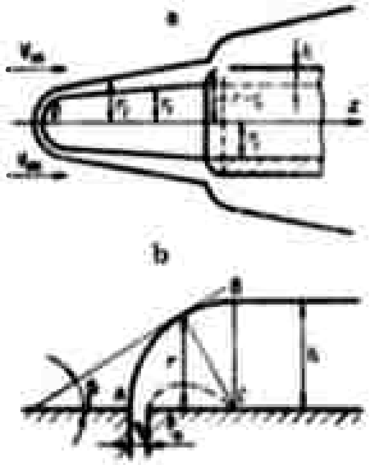


Fig. 1. Theoretical diagram: a) body of revolution with fan jet in downwash flow, b) meridian cross-section of equivalent body formed by the jet.

The concept of an equivalent body (Fig. 1b) is introduced to determine the depth h of fan jet penetration into the downwash flow. The generatrix of the equivalent body is represented by the arc AB = $\pi/2$ with a central point C and radius r. The depth h, equal to the height of the equivalent body, is determined from the equality of the jet aerodynamic force A_1 on the equivalent body to the jet flow momentum per unit time through the radius BC surface of revolution. When calculating A_1, it was assumed that the flow in the volume ABC is adiabatic, the gas is perfect, the zero-slip point coincides with C, and the gas flow velocity through the BC cross-section is determined by isentropic expansion. The radius r_2 of the shock wave in the vicinity of the body in t first approximation by analogy with a cylindrical explosion is determined to be

$$r_2=\left(\frac{E}{\varkappa_\infty \alpha(\varkappa_\infty) P_\infty}\right)^{\frac{1}{4}}\left(\frac{x}{M_\infty}\right)^{\frac{1}{2}}. \qquad (1),$$

where X_∞ is the ratio of specific heat capacities, $\alpha(X_\infty)$ is a constant for a given X_∞, P is the pressure, M_∞ is Mach number, and E is the explosion energy per unit length. The shock wave shape is determined from the equalities of E with the body drag A ahead of the injection cross-section x_0, at h maximum, and behind the x_h cross-section. Application of the cited formulas to a calculation of the shock wave shape around a spherically-blunted cone is illustrated in Fig. 2 by the curve adc. Curve ade illustrates

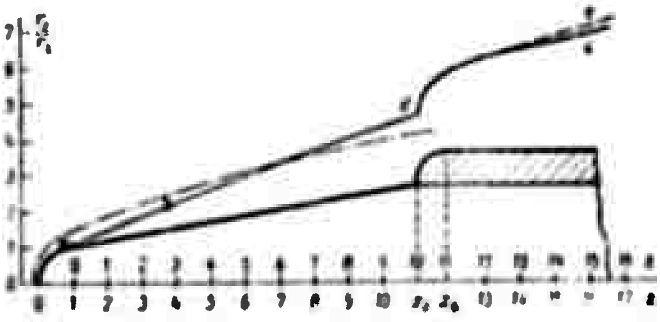


Fig. 2. Illustration of calculations: r_3 is the radius of blunt nose curvature $z = x-r_3/r_3$.

the shock wave shape calculated in a second approximation, with allowance for counter-pressure. The discrepancy between the approximations is $\leq 3\%$ at $z = 15$, but could reach 10-20% at $M_\infty = 1$-5.

Korobeynikov, V. P., P. I. Chushkin, and K. V. Sharovatova. Gazodinamicheskiye funktsii tochechnogo vzryva (Gas dynamic functions of a point explosion). Vychislitel'nyy tsentr AN SSSR, 1969, 48 p. (RZhMekh, 7/22, no. 7B221K)

This monograph analyzes the problem of a point explosion with counterpressure in a stationary, inviscid and non-heat conducting gas having a constant adiabatic index γ. The pressure and density of the ambient gas are taken as constant over an arbitrarily large volume. The treatment is given in five sections as follows: (1) method for calculating dimension loss gas dynamic functions; (2) construction of tables and formulas for determining the physical parameters of an explosion; (3) calculation of certain additional characteristics of gas flow; (4) use of the tables to solve specific gas dynamic problems; (5) tables of gas dynamic functions of a point explosion.

Tabulated calculations are given for flat, cylindrical and spherical explosions in gas at γ values of 1.3, 1.4, and 5/3. The tables include basic functions defining the gas flow field over long time intervals. The work is presented as an extension of similar data on initial stages of an explosion, as previously calculated by the authors and others. Possibilities are also pointed out of using this tabulated data for solving other problems in explosion gas dynamics, as well as in hypersonic aerodynamics.

Barinova, T. Ya. Plane waves in nonideal elastic medium with lag. IAN Tadzhikskoy SSR, no. 1, 1972, 14-19.

The propagation of plane SH and SV shear and compression waves in compact and loose rocks is analyzed theoretically, based on seismic wave propagation in real solid media. The analysis uses Gurevich's model which allows for wave absorption by the medium. SH and SV waves are described by a u(x, y, z, t) function which is expressed in terms of complex numbers to satisfy the equation of wave propagation in the Gurevich model. The complex numbers represent the projections k_x, k_y, and k_z of the wave vector k(ω) on coordinate axes. The compression wave is similarly described by the φ (x, y, z, t) potential and an equation for k(ω). Two kinds of shear and compression waves were examined. The phase velocities and coefficients of wave absorption were formulated on the assumption that the planes of equal phases are either parallel or nonparallel to those of equal amplitude. In the first case, wave attenuation proceeds in the direction of the wavefront propagation and the wave is called "homogeneous" In the second case, shear waves propagate only along the z or x axis, if the angle of incidence θ of a ray = 0 or π/2, respectively. The absorption coefficient along the z axis increases, and that along the x axis decreases, with an increase in θ. Such waves are called "inhomogeneous" in an absorbing medium. The formulas for the phase velocity and the wave absorption coefficient are simplified for both the shear and the compression waves propagating in compact rocks (at a 3-4 km depth) or those rocks intermediate between compact and loose.

Kapustyanskiy, S. M., and K. N. Shkhinek. <u>Propagation of two-dimensional waves in an elastoplastic medium</u>. MTT, no. 3, 1972, 48-55.

The solution to an elastoplastic wave problem is obtained with an improved approximation which allows calculation of propagation at a c/D ratio higher than those previously used (c is the propagation velocity of a longitudinal wave in the medium and D is the constant propagation rate of a free surface load). The solution is based on patterns in the wave front and ray orthogonal coordinate system in parallel with a z-r Cartesian coordinate system (Fig. 1).

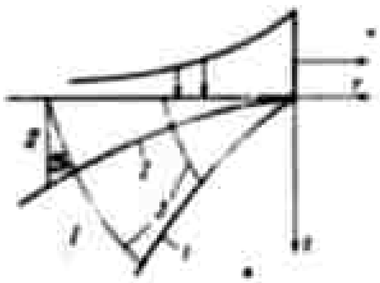


Fig. 1. Wave propagation pattern in an elastoplastic half space under load: 1 and 2 curves - longitudinal and transverse wave fronts; 3 - rays

An instantly applied maximum load is assumed to be normal to the Prandtl-Reuss plastic material surface boundary, obeying the Mises yield condition. The main flow propagates along the rays. The front transverse flow rate V_ν is an order of magnitude lower than V_τ of the main flow.

The approximate equations of motion for the medium behind the longitudinal wave front were solved for V_τ and σ_τ, the stress normal to the τ axis. The solution for V_ν in the first approximation was derived for a medium with a zero shear modulus. The V_τ, σ_τ, and V_ν first approximation formulas were further simplified for a homogeneous medium. The second V_τ and σ_τ approximations were calculated from the first approximation of V_ν, etc. The successive approximations of V_τ, V_z, and V_r were found to be similar even at a large α (see Fig. 1). The $(V_z)_o$ and $(V_r)_o$ data calculated from the one-dimensional formulas revealed a greater difference in comparison with V_z and V_r values of two-dimensional theory. It was concluded that, in contrast to the one-dimensional theory, even the first approximation of the two-dimensional theory yields satisfactory data at $G = 0$ the ratio of the transverse to longitudinal velocity squares in a $Z = 0$ cross-section. The number of approximations required to arrive at a solution with a given accuracy diminishes at decreasing G. Calculation examples are given for two approximations of the two-dimensional formulas to illustrate the effect of the medium coefficient of lateral pressure, α, and G, on propagation characteristics in the $z = 0$ cross-section and attenuation in depth of V and σ.

Zakharov, M. N., and I. N. Ivashchenko. Theory of plastic flow in soils. MTT, no. 2, 1972, 185-188.

The plastic deformation of clayey and sandy soils was investigated in hollow cylindrical samples under triaxial compression. The compressive load was applied by a leverage system in a vertical direction along the cylinder axis and hydrostatically in the radial and tangential directions. The

resulting principal strains σ_z, σ_r, and σ_T were measured with an accuracy to 0.01% for σ_z and 0.03% for σ_R and σ_T. The average applied pressure σ and the parameter $\mu = (2\sigma_2 - \sigma_1 - \sigma_3)/\sigma_1 - \sigma_3)$ of the stressed state were constant during loading. Experimental data are presented in the form of stress surface traces on the strain σ_i-σ coordinate plane. It was concluded from analysis of the traces that the stress surface in the principal strain field is closed and expands with an increase in σ. A general expansion of the surface is caused by irreversible plastic deformation of the soils. The traces perpendicular to the σ axis are not circular, but are extended in the direction of loading. A change in the loading direction (sign of μ) results in surface displacement, in addition to deformation, and a decrease in plastic deformation resistance in the original direction. The theoretical expression of the function σf describing a stress surface should include a plastic deformation tensor and the parameters of acquired anisotropy, besides the three stress components Sjk. The incremental plastic deformation vector de^p obtained by gradually applying load increments $d\sigma$ at stress surface points was found to be normal to the surface. Incremental loading caused additional volumetric strain. The experimental smoothness and convexity of the stress surface led to the conclusion that the formula associated with the stress surface

$$d\epsilon_{jk}^{p} = G \frac{\partial f}{\partial S_{jk}} df \qquad (1)$$

adequately describes soil plastic deformation.

Fokin, L. R. A method of determining the parameters of a unified thermal equation of state, based on experimental data from the saturation curve. TVT, no. 6, 1971, 1195-1199.

A method is developed for computing the derivatives $(dy/da_i)_{a_{j\neq i}}$ of thermodynamic functions with respect to the parameters $\bar{a}$ of the unified thermal equation of state

$$p = p(T, v, \bar{a}), \tag{1}$$

The method simplifies the calculation of (1) for single-component substances. The basic derivative expression

$$\left(\frac{\partial p_{sat}}{\partial a_i}\right)_{T, a_{j\neq i}} (v'' - v') = \int_{v'}^{v''} \left(\frac{\partial p}{\partial a_i}\right)_{T, v, a_{j\neq i}} dv. \tag{2}$$

was obtained by differentiation of the Maxwell equation with respect to a_i at constant $a_{j\neq i}$ and temperature. This simple expression can be used for calculating (1) with allowance for the experimental p_{sat} data. From (1) and (2) the expression

$$\left(\frac{\partial y'}{\partial a_i}\right)_T = \left(\frac{\partial y}{\partial a_i}\right)_{T, v} + \left(\frac{\partial y}{\partial v}\right)_{T, \bar{a}} \left(\frac{\partial v'}{\partial a_i}\right)_T. \tag{3}$$

was derived for y' or y'' functions in the single-phase region on a saturation curve. Differentiation of the Clapeyron-Clausius equation gave the expression for the derivative $(dr/da)_T$ of the heat of vaporization r $(T, \bar{a})$. New derivatives

$$\frac{\partial}{\partial a_i}\left[\left(\frac{\partial p}{\partial T}\right)_v\right]_T, \quad \frac{\partial}{\partial a_i}\left(\frac{\partial^2 p_{sat}}{\partial T^2}\right)_T \text{and } \frac{\partial}{\partial a_i}\left[\left(\frac{\partial v}{\partial T}\right)_p\right]_T. \tag{4}$$

for the two-phase region were obtained by differentiation of C_v^{tp} (T, v, $\bar{a}$) with respect to a, where C_v^{tp} is specific heat at constant volume in the two-phase region. Using (1) and the expression $(dv'/da)_T$, the derivatives $(dz/da)_{T,\rho}$ and $(d\rho''/da)_T$ were determined, where $z = pv/RT$ is the compressibility factor and $\rho'' = 1/v''(T)$ is the orthobaric density. Both the derivatives $(dz/da)_{T,\rho}$ and $(d\rho''/da)_T$ serve to calculate the derivative $(d\Phi/da)_{T,\Delta H_0^o}$ of the Gibbs function Φ (T, 1 atm).

Migdal, A. A. Equation of state near the critical point. ZhETF, v. 62, no. 4, 1972, 1559-1573.

A phenomenological approach to thermodynamics of second order phase transitions is used to derive a universal equation of state and expressions for all thermodynamic quantities. Within the Landau theory on expansion of the equation of state into powers of an order parameter, the equation of state for ferromagnetics near the Curie point is expressed by the function $\varphi(m)$ whose argument $m = M\chi^{\beta/\gamma}$ where M is the magnetization, χ is magnetic susceptibility, and β and γ are phenomenological parameters or critical indices. Since the theoretical and experimental β and γ values are the same for ferromagnetics and gases, their equations of state are similar. It follows from the similarity rule that $\varphi(m)$ is explicitly independent of temperature. It is also shown that $\varphi(m)$ does not exhibit singularities in the critical region and can be expanded into the rapidly converging series

$$\varphi(m) = m + \varphi_3 m^3 + \varphi_5 m^5 + \dots \tag{1}$$

In the first approximation, the initial two terms of (1) are retained, and

β and γ indices are correlated by

$$\beta + \gamma = {}^{3}/_{2}. \tag{2}$$

The equation of state in parametric form becomes

$$(-\varphi_3)^{1/2} M = r^{\beta}\Theta, \quad (-\varphi_3)^{1/2} H = r^{\beta+\gamma}\Theta(1-\Theta^2),$$
$$C_+^{-1/\gamma}\tau = r(1 - 3\Theta^2/2\gamma), \quad \chi = \dot{r}^{-\gamma}. \tag{3}$$

where H is the magnetizing field and $\theta^2 = -\varphi_3 m^2$. Equations (3) coincide with the empirical equations of Schofield, et al [Phys. Rev. Lett., 23, 1969, 1098]. The formula (2) agrees with the experimental data within 5-10%. The agreement is better if the third term in (1) is retained. The second approximation of the parametric equation of state can accordingly be written in the form

$$\tau = r(1 - b^2\theta^2), \tag{4}$$
$$M/M_c = r^{\beta}\theta[1 + (2\beta + 2\gamma - 3)b^2\theta^2]^{(3\beta-\gamma)/(2\beta+2\gamma)}, \tag{5}$$
$$H/H_c = r^{\beta+\gamma}\theta(1 - \theta^2 + \lambda\theta^4), \tag{6}$$
$$\left(\frac{\partial M}{\partial H}\right)_{\tau} = \chi = \frac{M_c}{H_c} r^{-\gamma}[1 + (2\beta + 2\gamma - 3)b^2\theta^2]^{-5\gamma/(2\beta+2\gamma)}. \tag{7}$$

where the parameter $\theta = \Theta$ in (3), when the correlation (2) is retained. The coefficient λ is given as

$$\lambda = \frac{\beta}{\beta+\gamma}(2\beta + 2\gamma - 3)^2 b^4. \tag{8}$$

Equations (4)-(7) are universal in form and depend on β and γ only. The accuracy of the calculations increases only slightly by adding the succeeding terms of the (1) series owing to the present level of accuracy of the experiment.

Vasserman, A. A., and A. Ya. Kreyzerova. Computerized method based on experimental P-V-T data for synthesis of an equation of state of a liquid. ZhPMTF, no. 2, 1972, 119-124.

A method is described for machine computation of an equation of state of a liquid, based on the simultaneous determination of the coefficients A, B, C... in the equation

$$p = A(T)\rho^{n} + B(T)\rho^{n+2} + C(T)\rho^{n+4} + \ldots \tag{1}$$

using the least squares method. A computerized method, previously developed by the authors [IAN BSSR. Fiz-energ. n., no. 1, 1971] and based on successive determinations of the same coefficients, required input of P-V-T experimental data for each isotherm and imposed limitations on the form of the equation. Equation (1) of the present method is valid for liquids and compressed gases of a reduced density $\omega > 1.8$.

The method algorithm is a step-by-step process. The basic sequential steps are: preliminary determination of the weight $1/\Delta p^2$ of each experimental point by computing an approximate equation of state with n = 1 and without allowance for $1/\Delta p^2$, and calculating Δp from

$$\Delta p = \rho\delta\rho\,(\partial p / \partial\rho)_T \tag{2},$$

where Δp is the permissible variation of p ; synthesis of two equations of state with n = 1 and n = 2 and with allowance for $1/\Delta p^2$; selection of optimum n, usually in the 1-2 range; determination and storage of the coefficients of the unknown equation of state; calculation of the ρ values in each operating point by solving the computed equations; determination and storage of the $\delta\rho$ data, i.e. relative deviations from the experimental value; determination of the points at which deviations exceed a preset permissible value, with automatic

correction of $1/\Delta p^2$ of each isolated point; and formulation of a new variant of the equation of state. The last two steps are repeated as many times as necessary until $\Sigma\delta\rho^2$ of the isolated points ceases to decrease. The minimum $\delta\rho^2$ determines the optimum variant of the equation of state. The Minsk-22 computer programming allows formulation of an equation of state with 3-4 temperature functions and a maximum of 28 coefficients.

The method was used to synthesize equations of state of liquid nitrogen, argon, and CO_2. The experimental data used were in the ranges: 63.6-140°K and up to 709 bar; 85.7-173.2°K and up to 1,186 bar, and 219.2-329.4°K and 6-2493 bar for nitrogen, Ar, and CO_2, respectively. Several equations of state were obtained for each of the liquids. The optimum equation variant coefficients of each liquid are tabulated in Table 1.

$$p = \rho^n \sum_{i=0}^{k} a_i \theta^i + \rho^{n+2} \sum_{i=0}^{l} b_i \theta^i + \rho^{n+4} \sum_{i=0}^{l} c_i \theta^i + \rho^{n+6} \sum_{i=0}^{s} d_i \theta^i$$

$$(\theta = T/100)$$

Coefficient	N_2 ($n=1$)	Ar ($n=2$)	CO_2 ($n=2$)
a_0	1921.335	−882.8222	−1758.230
a_1	−2005.639	791.366[illegible]	679.5640
a_2	650.8802	19.1[illegible]	6.252337
a_3	—	37.19111	—
a_4	—	73.[illegible]	—
a_5	—	[illegible]	—
b_0	−11565.26	−418.[illegible]	−244.5904
b_1	9[illegible]3.481	[illegible]	−18.[illegible]2383
b_2	−1[illegible]57.699	—	−63.69379
c_0	8[illegible]19.182	193.[illegible]	−260.2592
c_1	−2695.553	69.[illegible]	−201.2977
c_2	20.18530		192.1[illegible]38
d_0	—		−188.3002
d_1	—		502.79[illegible]1
d_2	—		1[illegible].4705

Table. 1. Coefficients of temperature functions for liquid nitrogen, argon, and CO_2 equations of state.

The rms deviation of the P-V-T data from the experimental data, obtained using the tabulated equations, was 0.13% for nitrogen and argon and 0.08% for CO_2. A further increase of the number of coefficients in the equations of state does not contribute to increased accuracy in the description of the experimental data. It was shown that the experimental data are described with the same accuracy by equations with a uniform coefficients distribution between temperature functions and a linear C (T) function (and D(T) function for CO_2), but not by the equations with a linear A(T) function. The A(T) function is the most complex of the T functions in keeping with its physical interpretation.

Zuyev, V. Ye., A. V. Kuzikovskiy, V. A. Podogayev, S. S. Khmelevtsov, and L. K. Chistyakova. Thermal effect of optical emission on small water drops. DAN, v. 205, no. 5, 1972, 1069-1072.

The authors note that in the bulk of material dealing with laser transmission through fog or clouds, no allowance is made for discrete variations in the heating and evaporation regimes of the droplets. A theoretical analysis is accordingly made which distinguishes five possible heating modes in terms of droplet size and absorbed power density, as shown in Fig. 1.

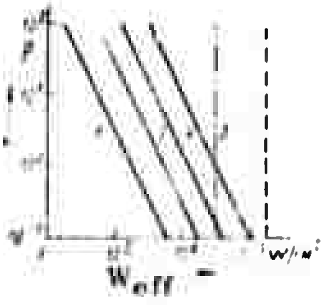


Fig. 1. Evaporation modes of a spherical droplet in an optical field. r = drop radius, W_{eff} = absorbed power density

Region 1 is characterized by a relatively high thermo-conductive loss, and a nearly linear relation of evolved vapor mass to droplet surface temperature. In region 2 the evaporation rate begins the rise nonlinearly with temperature, so that heat conduction loss in the vapor becomes less of a factor. In region 3 the conductive loss is considered negligible, and hydrodynamic action of the vapor becomes the dominant effect in mass and heat transfer.

The foregoing are all stationary temperature modes; in region 4 the temperature field within the droplet becomes nonstationary and droplet boundaries become unstable; here evaporation is due primarily to hydrodynamic action. Finally in region 5 explosion occurs, as the internal heat in the drop exceeds criticality.

Supporting test data from other authors is included to confirm the analysis. These were for $\lambda = 3.39\mu$, W_{eff} = [illegible] w/cm^2, and $\lambda = 10.6\mu$, $W_{eff} = 22\ w/cm^2$ and used drops on the order of 20 μ diameter, which is in the cloud droplet range. A comparison of test and theory is given in Fig. 2, showing reasonable agreement.

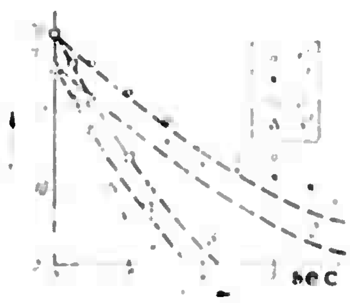


Fig. 2. Droplet radius decrement vs. time under laser irradiation. 1-4, theory; 1'-4', experiment.

Kallistratova, M. A., and V. V. Pokasov. <u>Correlation measurement of "wandering" optical centers of gravity of spatially limited beams in the atmosphere</u>. IVUZ Radiofiz, no. 5, 1972, 725-731.

Theoretical and experimental results are discussed on the "wander" characteristics of a laser beam center of gravity, for the case of propagation in the surface boundary layer. Rather than considering a single beam, the authors use the more general model suggested by Kon (IVUZ Radiofiz, in printing) which considers a compound beam having converging, diverging or parallel optical axes. Using Kon's notation, the authors experimentally determine the correlation coefficients of axis wander vs. atmospheric turbulence for the three cases ($b\rho_1$, $b\rho_2$ and $b\rho_3$, respectively) and compare the results with theory.

Tests were run with He-Ne lasers over horizontal paths at the Tsimlyansk (250 m) and Zvenigorodsk (650 m) stations of the Institute of Atmospheric Physics during the autumn of 1968 and 1970. To determine instantaneous wander correlation a scanned receiver was used as shown in Fig. 1 in which the received beam was chopped by a rotating mirror and vertical slit whose combined output was fed to a photomultiplier. By using orthogonally polarized beams and corresponding polaroid filters, the intensity variation in each beam could be viewed simultaneously as indicated in the diagram. Mirror rotation period was on the order of several milliseconds, which was considered fast enough to detect instantaneous turbulence effects. In this way the correlation of intensity variation was found as a function of ρ/a, where ρ is beam separation and a is initial effective beam radius

(See Figure 1 on next page)

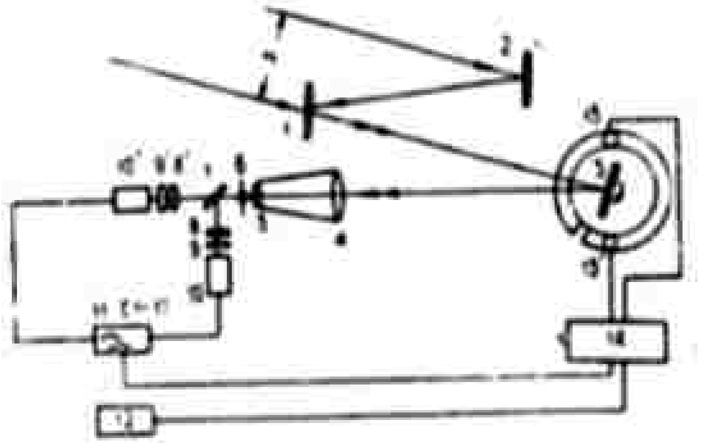


Fig. 1. Receiver diagram

1, 2- combined beam; 3- mirror; 4, 5- focusing lenses; 6- vertical slit; 7- 50% mirror; 8, 8'- polaroid filters; 9, 9'- interference filters, 40Å; 11- scope; 12- camera; 13- photodiodes; 14- synchronizer.

Results for converging and diverging beams are shown in Fig. 2 where they are compared to the theoretical results predicted by Kon's formulas. (See Figure 2 on next page). Reasonably good agreement is seen in the divergent beam case (2a), but correlation is noticeably less for convergent beams than predicted by theory (2b). The reason for this difference remains unclear, since the same techniques and simplifying assumptions were used in treating both types of transmission.

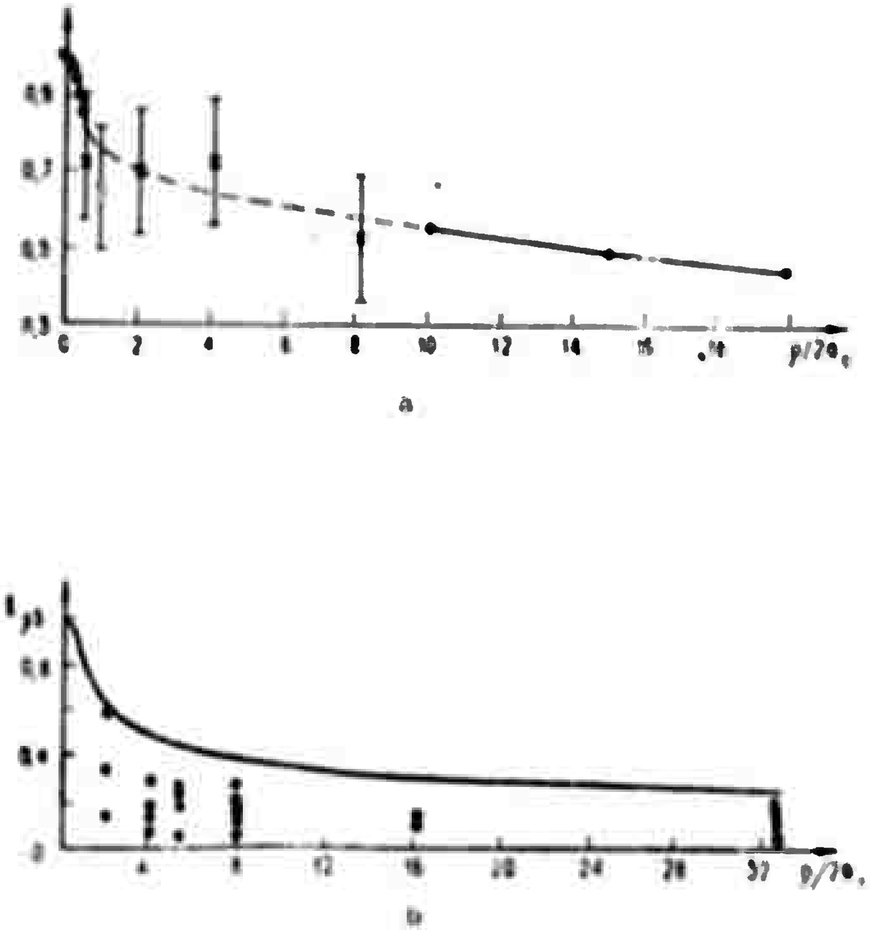


Fig. 2. Wander correlation

a - diverging beams; b - converging beams.
Vertical lines show rms error, curve - theory

Starobinets, I. A. Average illumination and fluctuation intensity of a light beam focus in a turbulent atmosphere. IVUZ Radiofiz, v. 25, no. 5, 1972, 738-742.

The defocusing of a light beam focused in a turbulent atmosphere was calculated in three works by other authors, and like results were obtained although the problem was solved by different methods. The relationships outlined in these works were experimentally confirmed by Kallistratova and Pokasov (IVUZ Radiofiz, v. 14, no. 8, 1971, 1200). Measurements were conducted on the defocusing of a beam focused in the atmosphere by a much more simplified procedure than the one employed by Kallistratova. A procedure is proposed for measurements of turbulence intensity on the basis of measurements of the mean illumination in a focused light beam. The relationship of the effective diameter of a light beam in the focal plane to the aperture diameter of the focusing system under conditions of strong turbulence was experimentally verified. Results of measurements of dispersion of the intensity logarithm are presented for a variation of the mean-square phase difference of a beam aperture in excess of 10 π.

S"yedin, V. Ya., S. S. Khmelevtsov, and R. Sh. Tsvyk. Intensity fluctuations in a focused beam passing through turbulent atmospheric layer. IVUZ Radiofiz, v. 14, no. 5, 1972, 798-800.

The authors report investigations of intensity fluctuations in a focused beam along the optical system axis as well as in a randomly wandering beam, and discuss application of the results of K. S. Gochelashvili (IVUZ Radiofiz, 14, no. 4, 592, 1971) for formulating

fluctuations in a focused beam. Intensity measurements were done by two methods, descriptions of which are briefly outlined i.e. on 20 - 1360m paths over a highly uniform region, and on a 3.5km path over rough terrain. The radiation sources used were an LG-35M laser (λ = 0.63μ), and a special ruby laser with reflecting telescope system having a maximum diameter of 260 mm, and a radial scatter close to diffractional. Computer calculations according to photometric results showed that the dispersions of logarithmic intensity fluctuations practically did not depend upon the randomly wandering beam in the focal plane. Structural constants of temperature fluctuations C_T^2 and refractive index fluctuations C_n^2 were determined. Values of structural function D_ϕ of phase fluctuations were calculated from the following relationship:

$D_\phi(\rho) = 3/8 \cdot 2.91\, C_n^2 L K^2 \rho^{5/3}$, where

L - propagation distance

K - $\frac{2\pi}{\lambda}$, λ = wavelength

ρ - effective beam dimension at transmitter output

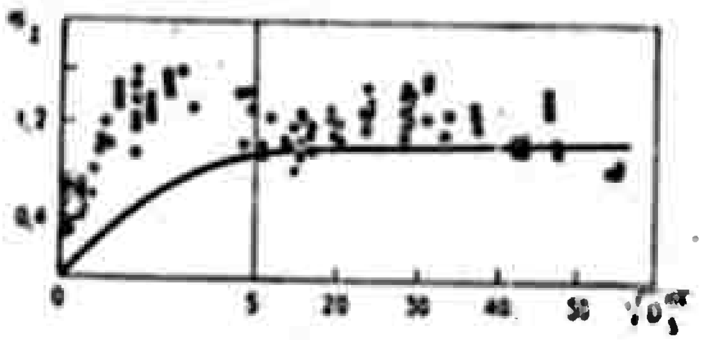


Fig. 1. Comparison of measured intensity fluctuations in the focus vs. calculated results.

●●● - Ω = 5-10; ooo - Ω > 10

—— calculated by Gochelashvili

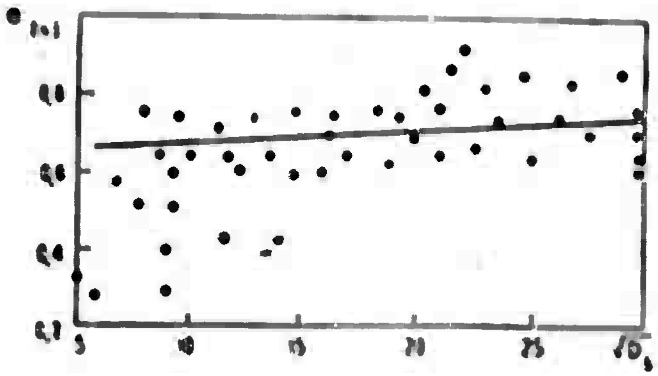


Fig. 2. Results of logarithmic intensity fluctuation measurements in the accidental stray focal point (photographic method).

Figure 1 shows the dispersion of intensity fluctuations along the system axis. It is seen that the experimental points in the lower D_s region are significantly higher than calculated, and a sharp decrease of the mean square of the intensity function occurs at $D_s < 1$. In Figure 2, the level of fluctuation is less than that reported by M. Ye. Gracheva, et al (RiE, no. 6, 1970, 1290), which shows, according to the authors, that the random wandering beam significantly affects the dispersion of intensity fluctuations.

Naumov, A. P. Radiowave absorption by gas impurities in the atmosphere. IVUZ Radiofiz, v. 25, no. 5, 1972, 682-694.

Quantitative data are presented on the molecular absorption of centimeter, millimeter, and submillimeter radio waves ($\lambda \geqslant 0.33$ mm) by the atmospheric gas impurities O_3, CO, and N_2O at altitudes of 0 and 20 km. Data on the atmospheric total absorption coefficient in the millimeter and centimeter ranges for altitudes of 0, 15, and 20 km are also given. The shielding effect is discussed of the principal absorption components of the atmosphere (water vapor and molecular oxygen) on the resolution of rotational lines of the impurities in the total absorption coefficient for various altitudes (0, 10, 15, and 20 km). The results can be used for refinement of the propagation characteristics of the pertinent radio waves in absorption resonance regions of the specified impurities at high altitudes, and for estimating the potential of infrared-radar atmosphere research.

Kozyrev, B. P., and V. A. Bazhenov. Measurement of atmospheric vertical transparency in the infrared region using an artificial source. FAIO, v. 8, no. 5, 1972, 552-556.

A light beam reflector from an artificial source was developed for balloon-borne measurements of vertical atmospheric transparency. A variant of corner reflector was used, with three mutually-perpendicular flat aluminized mirrors, provided with units for precise right angle adjustment between the mirror surfaces. The device eliminates the drawbacks of limited spectral passage and the difficulty of constructing a highly precise right tetrahedron characteristic of prism corner reflectors. Using the triple-mirror method it is feasible to measure the vertical transparency of the lower atmospheric layers on cloudy days as well as at night. The principal condition of precise establishment of a right angle between the mirror planes of the reflector for measurements of attenuation of the medium enclosed between the artificial light source and the triple mirror, is complied with by use of the beam reflector device.

Test measurements show that at 1.05 mm, 1.22 mm, 1.65 mm, and 2.2 mm wavelengths the infrared radiation attenuation in the transparency windows of the atmosphere may reach 2-10% in the lower 500 meters of the surface boundary layer. Attenuation in this region comprises 50-60% of the total attenuation of the air column. Integral 500 m transmission in the atmospheric layer within the 0.7-40μ range approaches 40-50%.

Shem'i-Zade, A. E. Seasonal extremes in concentration of nuclear fission products in the atmosphere. Atomnaya energiya, v. 32, no. 4, 1972, 350-352.

On the basis of the maxima and minima patterns of radioactive-fragment concentration in the surface layer of the atmosphere, conclusions are given on the intensity of the transfer into the troposphere of stratospheric air masses contaminated by fission fragments. According to published data and research by the author, the maximum contamination of the atmospheric surface layer by radioactive aerosols is observed in spring, and the minimum in the autumn. In years immediately following powerful injections of radioactive fragments into the stratosphere, the seasonal extremes are manifested very sharply. Subsequently, the less the total activity of fission fragments in the entire atmosphere, the less obvious are the seasonal extremes. At a sufficiently low value of total activity, seasonal extremes may not be detected at all, since the absence of observed seasonal extremes is apparently an indication of the coincidence of fluctuation amplitudes of the radioactive contamination level that are linked to the stratospheric reservoir with fluctuation amplitudes originating under the influence of processes in the lower troposphere.

The decay rate of the concentration of radioactive fragments in the troposphere after the moment of the seasonal maximum is evaluated on the basis of the period of a half-reduction of the concentration, T, within the interval between the maximum and the minimum of the seasonal level. If ρ_0 is the concentration at the maximum, and ρ_T is the concentration at the moment T, the period of half-reduction of the concentration follows the formula:

$$T = 0.693 \frac{t}{\ln \frac{\rho_0}{\rho_t}} \qquad (1)$$

Calculations for 1963 and 1964 using formula (1) for Tashkent, East Germany (average data for 9 stations), and Budapest, yielded consistently similar periods of half-reduction of the fission-product concentration in the troposphere after the spring-summer maximum in these regions. The value of the seasonal maxima is thus determined by the reserve of radioactive fragments in the stratosphere. In a period when powerful nuclear tests capable of strongly influencing the atmospheric reserves of fission products are not being conducted in the atmosphere, the rate of stratosphere purification can therefore be evaluated on the basis of changes in the value of the seasonal maxima by computing the half-period of stratosphere purification:

$$T_{strat} = 0.693 \frac{t'' - t'}{\ln \frac{\rho_0'}{\rho_0''}}, \qquad (2)$$

where ρ'_0 and ρ''_0 are the average monthly concentrations of radioactive fragments in the maximum during time T' and T'', respectively. Computation of the rate of purification of the stratosphere from radioactive fragments on the basis of formula (2) for Tashkent, East Germany, and Budapest yield $T_{strat} = 5.7 \pm 0.1$ months.

Barzykin, V. V., E. A. Shtessel', F. I. Dubovitskiy, and A. G. Merzhanov. Heat transfer mechanism for thermal explosion of liquid explosives. FGiV, no. 2, 1971, 304-306.

The effect of complex convection heat transfer on the critical conditions of a thermal explosion was studied in a dinitrohydroxyethylnitramine (DINA) melt in double-wall cylindrical vessels with a diameter of F = 3.0-39.b cm, and a volume-to-F ratio = 2. DINA was selected because of its large yield of gaseous decomposition products and its low viscosity. These characteristics contribute simultaneously to bubble and natural convection. The experimental wall temperature was maintained constant by selecting an appropriate circulation velocity of the heat-transfer agent (glycerin) and wall thickness.

The temperature differential ΔT between the charge and the wall, coefficient ν of kinematic viscosity, and density ρ versus T were measured. Tabulated experimental data are presented as a plot of δ_*/δ_0 versus Rayleigh number Ra (Fig. 1),

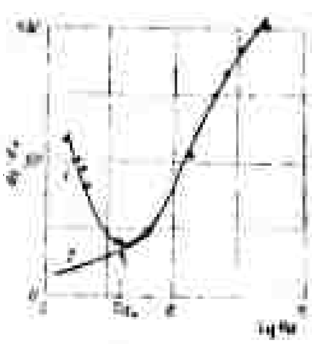


Fig. 1. Critical parameter of thermal explosion versus Rayleigh number: 1- DINA, 2- standard materials.

where δ_*/δ_0 is the relative critical Frank-Kamenetskiy parameter. For

the standard materials (curve 2), which react without gas evolution, the experimental relation

$$\delta_*/\delta = 1 + 0.062\,Ra^{1/3} \tag{1}$$

was established earlier by two of the authors (FGiV, v. 7, no. 1, 1971). A minimum on curve 1 at a critical $Ra_* \sim 10^7$ separates the regions of varying heat transfer mechanisms: mixing by bubbles at $Ra < Ra_*$ and natural convection at $Ra > Ra_*$. The Ra_* value is evidently different for each liquid explosive. It is concluded that the heat transfer below Ra_* proceeds by the mechanism of gaseous reaction products mixing while above Ra_* a natural convection mechanism prevails.

B. Recent Selections

i. Shock Wave Effects

Borovoy, V. Ya., M. V. Ryzhkova, and Ye. V. Sevast'yanova. Experimental investigation of gas flow and heat transfer in three-dimensional interaction zones between a laminar boundary layer and shock waves formed near a cylindrical obstacle and a half wing. IN: Sbornik. Teplo- i massoperenos, v. 1, part 3, Minsk, 1972, 104-113. (RZhMekh, 10/72, no. 10B779).

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Polyakov, Yu. A., and G. N. Nikolayev. Radiative heat transfer behind a reflected shock wave in two-phase flow. IN: Sbornik. Teplo- i massoperenos, v. 1, part 3, Minsk, 1972, 265-269. (RZhMekh, 9/72, no. 9B926)

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Yakusheva, O. B., V. V. Yakushev, and A. N. Dremin. Opacity mechanism of shock-compressed organic liquids. High Temperature-High Pressure, v. 3, no. 3, 1971, 261-266. (RZhF, 7/72, no. 7D464)

ii. Hypersonic Flow

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3. Geosciences

A. Abstracts

Kovalevskiy, G. L., V. V. Loktsik, and Ye. M. Averko. Dynamic characteristics of diffracted seismic waves. Geologiya i geofizika, no. 5, 1971, 89-99.

The results of an ultrasonic three-dimensional model study of the dynamic characteristics of seismic waves diffracted at an edge bordering a layer, as well as at an isolated (single) small surface are described. They are compared with the results of field measurements in a fault zone in the West Siberian platform. It was found that waves diffracted at the edge of a layer have maximum amplitude at x_k, the distance corresponding to the intersection point of the time distance curves of the waves diffracted along a sharply discontinuous layer and the waves reflected along a continuous layer. The maximum amplitude is equal to one half of the amplitude of the reflected waves. The diffracted waves alternate according to an inverse power law and they do not depend on the reflection coefficient, but mainly on the angle of emergence from the edge. The amplitude distance curve of the total waves above a discontinuous layer is characterized by a segment of increased amplitude Δ_m and by a segment of rapid decrease of amplitude symmetrical to x_k. The width of Δ_m increases with depth h. Thus, with an increase of the depth of the discontinuous layer, the tracking interval of the diffracted waves increases.

The ratio of the maximum amplitude of waves diffracted at an isolated surface and the amplitude of reflected waves decreases as the width of the surface decreases and the depth to it increases. The dependence of the amplitude of diffracted waves upon the reflection coefficient decreases as the width of the surface decreases. The results of the model study are in agreement with the field observations above a reflection interface or individual short segments bounded by faults, although they show a more rapid attenuation factor.

Bezrodnyy, Ye. M. Characteristics of the stress state of the earth's crust in the transition zone from orogeny to platform. IN: AN UzbekSSR. Institut seysmologii. Seymologiya i seysmogeologiya Uzbekistana (Seismology and seismogeology of Uzbekistan). Tashkent, Izd-vo Fan, 1971, 43-51.

The stress state in earthquake foci and at the earth's surface is analyzed for the Tashkent transition zone from the Chatkal - Kuramin orogeny (western spur of the northern Tien-Shan) to the Turanian plate. Focal mechanism solutions are obtained by Vvedenskaya's method for the following earthquakes: 1) Brichmullin, 24 October 1959, h = 15 km, E = 10^{14} j in the orogeny; 2) Tashkent, 24 April 1966, h = 8 km, E = 10^{13} - 10^{14} j in the transition zone; and 3) Kyzyl Kum, 13 March 1968, h = 25 km, E = 10^{14} j in the platform.

The three tectonic regions are characterized by type of stress state as follows:

Chatkal - Kuramin orogeny - $\sigma_2 > \sigma_3 > \sigma_1$ (subscripts indicate: 1- the principal stress axis is horizontal and normal to the strike of the surface tectonic structures; 2- horizontal and parallel; and 3- vertical). Horizontal tension and horizontal compression parallel and normal to the tectonic structures, respectively, prevail at the surface of the earth ($\sigma_3 = 0$). Relatively nonuniform horizontal tension and compression parallel and normal to the surface structures, respectively, prevail at depth ($\sigma_3 \neq 0$).

Tashkent transition zone- $\sigma_3 > \sigma_1 > \sigma_2$. A nonuniform compression is parallel to the tectonic structures at the surface, and a relatively nonuniform compression at depth.

Turanian plate - a) If the earthquake is considered to be confined to the faults with a northwestward strike, then $\sigma_1 > \sigma_2 > \sigma_3$ and the relatively nonuniform tension is normal to the tectonic structures, and b) if the earthquake is confined to the north-east trending Kyzyl Kum fractures with a northeastward strike, then $\sigma_2 > \sigma_1 > \sigma_3$ and the relatively nonuniform tension is parallel to the fractures.

Orlov, V. S. Identification of P and PS waves, using the converted-wave method and Zemlya seismic recording units. IN: AN TurkSSR. Izvestiya. Seriya fiziko-tekhnicheskikh, khimicheskikh i geologicheskikh nauk, no. 6, 1971, 106-109.

A method is proposed for the identification of PS waves using the Δt_{PS} = const criterion. If the P-wave train on a vertical seismogram at the i-th filtering is $f_i(t)$, then the PS wave on the horizontal seismogram (with delay time Δt_{PS}) is $k_i f_i\ (t - \Delta t_{PS})$.

If extrema of the P-wave train occur at

$$t_1^{(i)},\ t_2^{(i)} \ldots t_n^{(i)} \tag{1}$$

and are roots of

$$\frac{d\ f_i\ (t)}{dt} = 0, \tag{2}$$

then, PS-wave extrema times are roots of

$$\frac{d\, k_i f_i\, (t - \Delta t_{PS})}{dt} = 0 \tag{3}$$

and will be equal to

$$t_1^{(i)} + \Delta t_{PS},\ t_2^{(i)} + \Delta t_{PS},\ \ldots,\ t_n^{(i)} + \Delta t_{PS} \tag{4}$$

From (1) and (4), it follows that the identical extrema of P and PS are those which are separated by Δt_{PS} = const, regardless of filtering. A deep crustal section along a sublatitudinal profile (north of the town of Ashkabad), determined by PS waves identified using the proposed method, is shown in Figure 1.

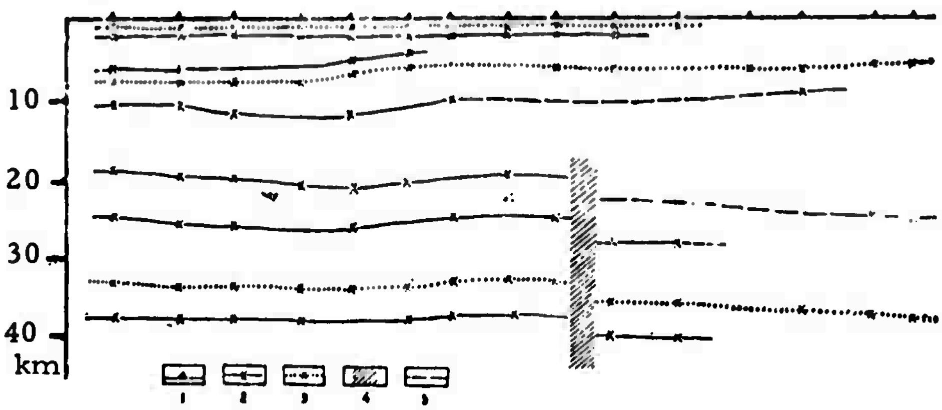

Figure 1. Deep Crustal Section

1- Observation points; 2- conversion point on a normal conversion interface; 3- conversion point on an anomalous conversion interface; 4- fault; 5- extrapolated conversion interface.

Anomalous conversion interfaces (PS waves have a polarity opposite to that of PS waves from other interfaces, as well as to that of P waves recorded by the same component) are found at depths of 1 km, 5 - 8 km, and 32 - 38 km.

Dimakov, A. I. Use of multiple compressional waves from distant earthquakes for the study of the structure of Earth's crust. Prikladnaya goefizika, no. 65, 1972, 43-52.

The results and techniques of a crustal study using multiple compressional waves from distant earthquakes are described. The criterion for the identification of multiple waves, as well as techniques for the determination of the V_P/V_S ratio, are given. An analysis is made of observational data obtained from crustal studies on the peninsula of Mangyshlak (Caspian Sea) performed in 1963-67 by the converted-wave method. Observations were made along the Karabogazgol-sor - Mertvyy Kultuk profile at 7 - 15 km intervals, and a velocity section is shown.

The waves, which were recorded on vertical seismograms with constant delay times in respect to P waves, were considered to be multiple ones, generated between the earth's surface and crustal interfaces ($P_1P_0P_0P_0$ type). The depths to interfaces were calculated using formulas for a two-layered medium with a horizontal interface. The relative errors of depth determination (δH) were estimated to be 4.6 and 7.5% for the Mohorovicic discontinuity and the top of the "granitic-metamorphic" layer, respectively. The errors due to neglecting to account for the dip of interfaces are analyzed. For the Mohorovicic discontinuity, these errors were found to be insignificant in depth determination and large in deflection determination, at dip angles of 5-7°.

The relation $k = V_P/V_S$ was calculated from multiple compressional and converted waves. The k(H) function is found to have the form

$$k = 1.41 + \frac{1.05}{H^{(0.25)}} .$$

The relative error δk is estimated to be 3.6% and 5.3% for the Mohorovicic discontinuity and the top of the "granitic-metamorphic" layer, respectively. It is included that the multiple compressional waves from earthquakes can be used in detailed crustal studies and the V_P/V_S ratio can be determined from multiple compressional and PS waves.

Abdullabekov, K. N., V. P. Golovkov, and Kh. A. Abdullayev. Study of seismomagnetic effect on the Tashkent geodynamic test site. IN: Uzbekskiy geologicheskiy zhurnal, no. 4, 1971, 6-8.

An analysis is given of the accuracy in determining the total geomagnetic-field intensity T at the Tashkent test site, as well as the initial results of the study of anomalies of geomagnetic field variations due to physical processes in the earth's crust. The Tashkent seismomagnetic test site consists of three traverses (total length 280 km with 4-5 km between observing points) established in 1968 with the aim of testing organizational and procedural techniques for future studies of seismomagnetic effects in Uzbekistan.

The accuracy of the PM-5 proton magnetometer used in the present study is 1.7γ. The error due to disturbances and non-identification of short period variations is negligibly low. The error due to the base value of T is 1.7γ. The rms error for a routine determination of T is 2.8γ. From the 5 - 9 September 1969 series of observations, the first results were obtained. Two local sectors with anomalous geomagnetic-field variation (-23γ and ± 10-15γ) were detected, whose source is believed to be in the earth's crust.

Shcherbakova, B. Ye., T. M. Lin'kova, and G. I. Semenova. Nature of waves recorded with Zemlya seismic recording systems in regions of East Siberia. Sovetskaya geologiya, no. 4, 1972, 88-101.

The results are given of a study of the nature of seismic waves from distant earthquakes (Δ = 28-90°) recorded by the horizontal component of "Zemlya" recording units along 1500 kilometers of profiles crossing the East Siberian platform and its folded confines, are given. These seismic waves (Figure 1) were identified as being converted transmitted waves related to crustal and upper mantle interfaces. The observations were made in three different geological regions: 1) the Irkutsk ampitheater of the platform with a 2.5 - 3-km-thick sedimentary cover (V_P = 5 km/sec; V_P/V_S = 2) and uniform crustal thickness; 2) intermontane depressions of the folded region with a 0.2 - 7.0-km thick sedimentary cover (V_P = 1.75-3.5 km/sec; V_P/V_S = 3.4-2.2) and variable crustal thickness; and 3) mountainous regions of the folded region without sedimentary cover and with variable crustal thickness.

Converted waves from deep interfaces were consistently recorded equally over all three geological regions, as well as in the regions with and without sedimentary cover and relative to the same interfaces. They are characterized by normal distributions of Δt_{PS-P} and are sometimes well correlated over 20 - 25-km-long sectors and sometimes uncorrelated over 2 - 5-km-long sectors of profiles, depending on the structure of the region.

The A_{PS}/A_{PP} ratio varies over a broad range, with predominant values of: 0.15 - 0.45 for the platform; 0.20 - 0.70 for the intermontane depression; and 0.15 - 0.40 for the mountainous region. The most intense converted waves are associated with the basement surface, an interface in the central part of "granitic" layer and the

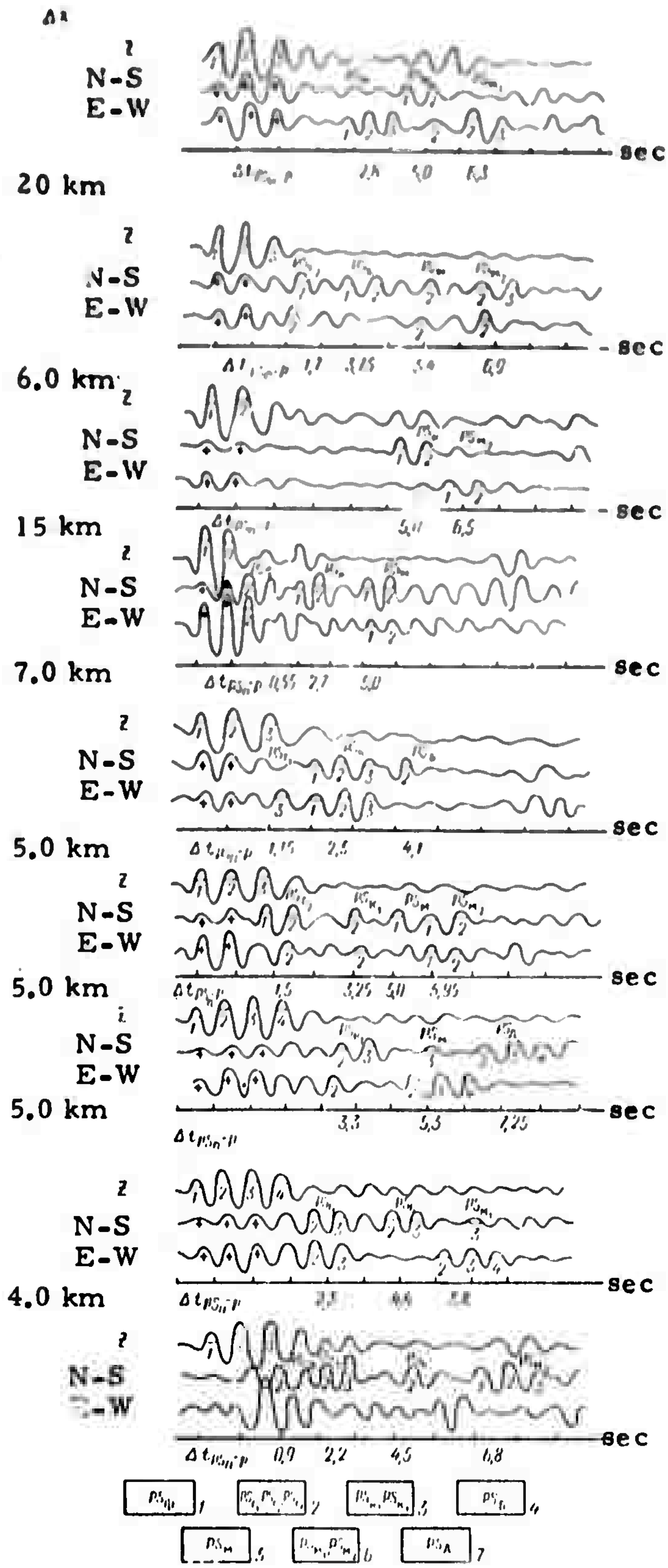

Figure 1. Seismograms Illustrating Records of Compressional and Converted Waves Recorded North of the Irkutsk Ampitheater. Earthquake of 12 August 1967 (▲ = 29°, α = 243°, Southern Pamir).

Δx- distance between recording points. PS- waves confined to: 1- basement surface (Φ); 2- interfaces within "granitic" layer (Γ_1, Γ_2, Γ_3); 3- interfaces within the transition zone between "granitic" and "basaltic" layers (k, k_1); 4- interface within lower "basaltic" layer; 5- Mohorovicic discontinuity (M); 6- interfaces within the transition zone between the crust and mantle (M_1, M_2); 7- interface within the upper mantle.

Mohorovicic discontinuity. The frequency and spectra of PS waves are similar to those of PP waves. Their polarization, being mainly elliptic, is highly diverse, depending upon the medium's structure and epicentral location. The major axis of the ellipse is sometimes deflected by 30-90° from the source direction.

Experimental and theoretical data are compared, and the amplitude ratio of compressional and converted waves are calculated for a thin homogeneous layer, a number of thin layers, and a thin transition layer having different velocity and density characteristics. The intensity of converted waves obtained for single-layered, multi-layered and sharp discontinuity (tabular values) models of a conversion interface are found to be sufficiently high for their identification on records.

The transmission coefficients and spectra of PP and PS waves calculated for a thin layer are found to depend on the h/λ_{2P} ratio (h- thickness and λ_{2P}- wavelength of incident wave). With narrow spectra of the incident P wave, the spectra of PS waves are shifted toward either higher ($h/\lambda_{2P} < 0.25$) or lower ($h/\lambda_{2P} = 0.5$-0.6) frequencies, relative to the spectra of PP waves. It is concluded that waves from distant earthquakes recorded by the horizontal component of the "Zemlya" system are correctly identified as having been converted at deep crustal and upper mantle interfaces.

Regional study of the earth's crust using Zemlya seismic recording equipment; Chapter III. IN: Glubinnoye stroyeniye zemnoy kory Uzbekistana po geologo-geofizicheskim issledovaniyam. Zapadnaya chast' Yuzhnogo i sredinnogo Tien'-Shanya (Deep crustal structure of Uzbekistan from geological-geophysical investigations). Tashkent, Izd-vo Fan, 1971, 42-50.

The results of seismological studies of the crustal structure in Central Asia performed in 1967 using converted transmitted waves are described. Observation of earthquakes were conducted along profiles I, II, and III shown in Figure 1. Recording stations were located 5-7 km (sometimes 10 km) apart. Recording was made with Zemlya seismic recorders with a passband 0.5 - 10 Hz and two vertical and two horizontal seismometers.

(see Figure 1 next page)

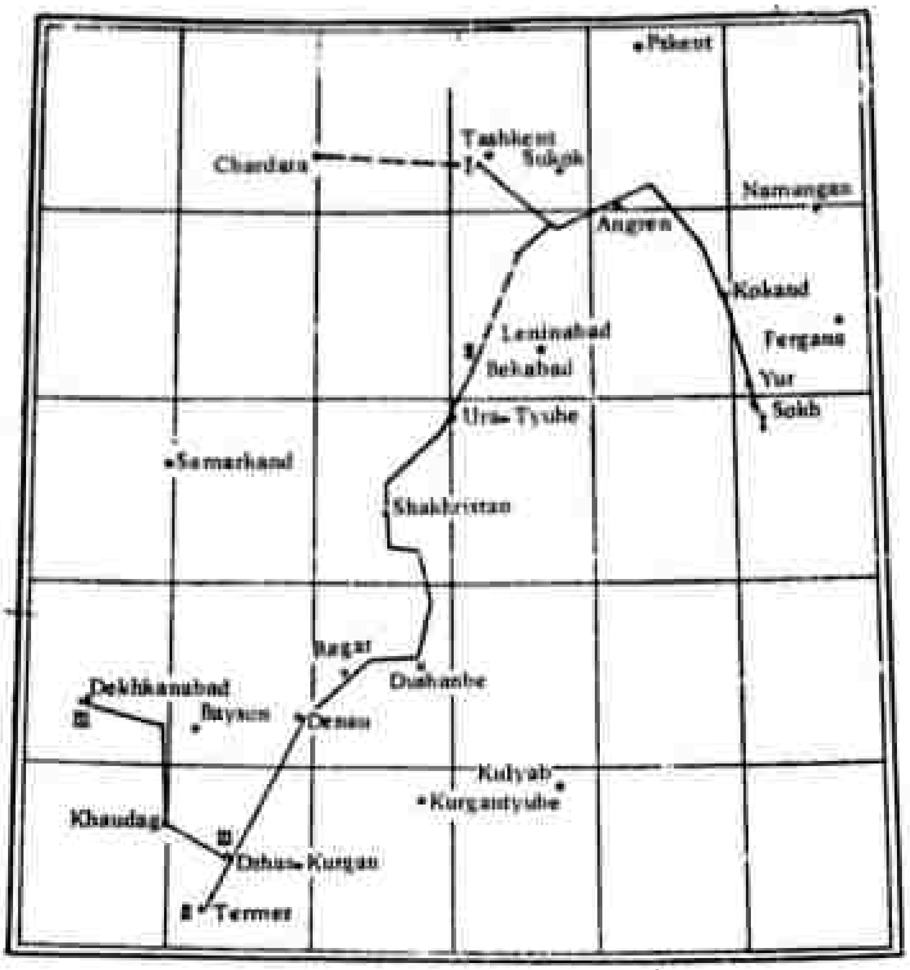

Figure 1. Location of Profiles of Observations with Zemlya Recorders.

The seismometers were placed on concrete pads in 1.5 - 2-m-deep holes.

Seismograms of 49 distant ($\Delta \geq 40^{\circ}$, various azimuths) and 28 near ($\Delta = 3$-40°, southern azimuths) earthquakes were used for the analysis. The wave field of distant earthquakes is characterized by a P-wave train duration not exceeding 1.0 - 1.5 sec and well correlated waveforms of P and PS-waves varying greatly with epicentral distances.

Continuous tracking intervals for converted waves are: PS_M with Δt_{PS-P} = 6.0 - 7.8 sec, confined to the Mohorovicic discontinuity; PS_K with Δt = 4.2 - 5.6 sec, confined to the Conrad discontinuity and PS_B with Δt = 2.5 - 3.0 - 3.8 sec, confined to interface B within the granitic layer (see Figure 2, a and b). Intense converted waves from upper-mantle interfaces with Δt ranging from 8 to 11 - 12 sec were tracked for short intervals. In zones with deep-seated faults, the wave field changes sharply.

(see Figure 2 next page)

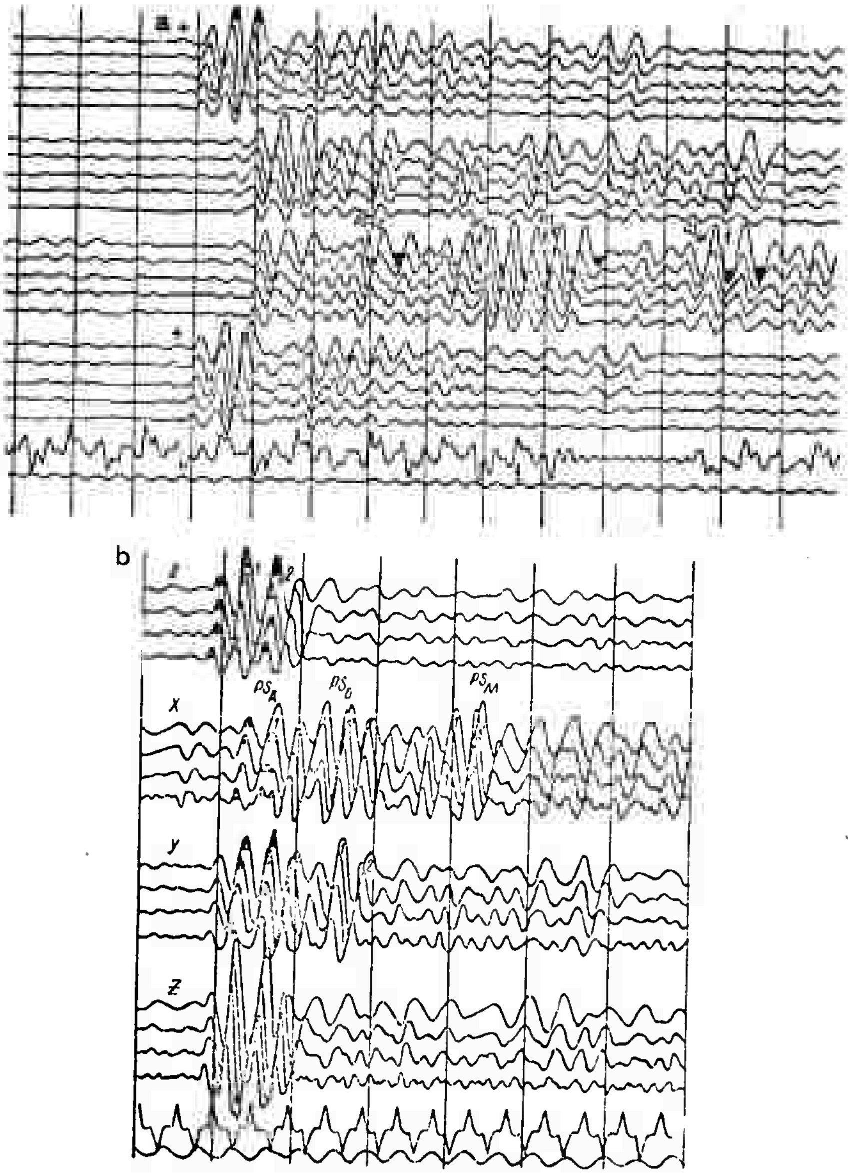

Figure 2. Converted-Wave Records
a - in Fergana Valley from Afghanistan earthquake 1749 hrs, 21 Dec 1967; b - at Kuraminskiy Ridge from Indonesian earthquake, 1926 hrs, 23 Feb 1968. PS_{PZ} - from the top of the Paleozoic basement; PS_A - from the top of, presumably, the Archeozoic basement; PS_B - from interface B within the granitic layer; PS_K - from the Conrad discontinuity; PS_M' - from an interface near the Mohorovicic discontinuity; PS_M - from the Mohorovicic discontinuity.

The crustal and upper mantle structure along profile I, as determined from converted waves of distant and near earthquakes, is given.

Among the other conversion interfaces, the most reliably identified were: the Mohorovicic discontinuity, the Conrad discontinuity, two interfaces within the granitic layer, surfaces of Archezoic and Paleozoic basement, and the top of Paleogene sediments in the Fergana Valley.

All the conversion interfaces have smooth relief, except in the zones of deep seated faults. All of them have flexure-like bends with amplitudes of 3 - 5 km in the North and South Fergana fault zones, while only the upper interfaces (up to 18 km) have bends with amplitudes of 1 - 1.5 km (in the Kumbel' fault zone).

A crustal thickness of 50 km is observed in the Fergana Valley, while for other parts of the profile, it is about 48 km. The thicknesses of the basaltic and granitic layers, 15 and 25 km, respectively, are constant along the entire profile.

The Mohorovicic discontinuity is particularly reliably identified in the southern part of the Fergana depression and in the Kamchik Pass - Akhangaran segment. A maximum depth of 50 km is observed in the center of the Fergana Valley; this decreases to 48 km toward the northern and southern edges of the valley.

The Conrad discontinuity is reliably identified along the entire profile except for the Akhangaran - Tashkent segment, and its relief conforms with that of the Mohorovicic discontinuity at a depth of 34 km and 30 km in the central part of the Fergana depression and the Kuramin ridge, respectively Bends observed in this interface have amplitudes of 4 km.

Interface B is identified reliably along the entire profile, except for the northern part of the Fergana Valley. This interface occurs at a depth of 27 - 28 km in the center of the Fergana Valley and rises steeply toward the Kuramin ridge, reaching a depth of 21 km near Tashkent.

Interface G relief conforms with interface B, at depths of 22, 13, and 14 km in the Fergana depression (22 km), Kamchik (13 km), and the Tashkent area (14 km).

The crustal thickness in the Surkhan Dar'ya depression (along the Dushanbe - Termez segment of profile II and along profile III) was found to be 37 - 40 km.

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4. Particle Beams

A. Abstracts

Mesyats, G. A., and Ye. A. Litvinov. Volt-ampere characteristic of a diode with a point cathode in an explosive regime of electron emission. IVUZ Fiz, no. 8, 1972, 158-160.

The authors consider the volt-ampere characteristics i (U) for explosive emission from a needle cathode, and arrive at a more rigorous expression than presented in cited earlier work. The case of a planar anode and cathode is assumed, with a metal needle normal to the cathode acting as the emitter (Fig. 1). The plasma flare developing around the exploding tip increases emission current, which is then limited by the space charge between the plasma front and the anode. The perveance P(i, U)

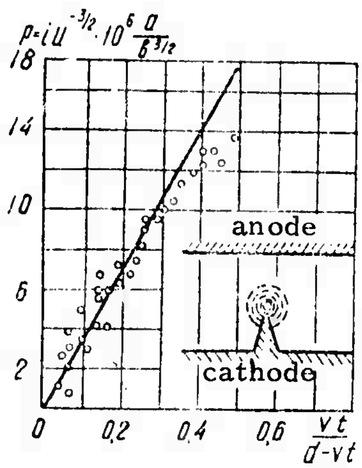

Fig. 1. Diode configuration and discharge characteristic.

is then defined by a power law which depends on the gap characteristic, i. e. the quantity vt/d-vt, where d = initial diode gap, v = plasma propagation velocity,

2×10^6 cm/sec, and t = elapsed time. Earlier authors have derived approximations for i(U) which are straightforward functions of system geometry and $U^{3/2}$; Mesyats refines this calculation to account for individual capacitance per unit area of emitting surface, rather than the gross capacitance assumed previously. This results in the integral characteristic

$$i = 2{,}33 \cdot 10^{-6} U^{3/2} \left(\frac{vt}{d - vt} \right)^{2\nu} (2\nu + 1) \int d\Omega P_\nu^2 (\cos \theta). \tag{1}$$

where $0 \leq \nu \leq 1$, $P_\nu(\cos \theta)$ is a Legendre function, and Ω is the aperture angle at the emitter tip, $\approx 2\pi$. Substituting arithmetical means for the coefficients in (1), the authors obtain the empirical expression

$$i = 37 \cdot 10^{-6} U^{3/2} \frac{vt}{d - vt}. \tag{2}$$

which agrees reasonably well with their experimental values, as seen in Fig. 1. The analysis thus verifies the "3/2" law of electron field emission from needle cathodes.

It must be emphasized that this analysis is limited to emission from the tip only, resulting in a spherical flare. For sufficiently strong applied voltage, local emission from the adjacent needle surface also commences, which would increase the rate of Eq. 2; this should be treated as a separate case.

Mkheidze, G. P., V. I. Pulin, M. D. Rayzer, and L. E. Tsopp. Limiting current of an uncompensated relativistic electron beam. ZhETF, v. 63, no. 1, 1972, 104-106.

The limiting current of an electron beam in vacuo was investigated in the absence of compensating ions. The beam was generated in a vacuum drift tube at a constant electron energy of 600 kev. Various values of R/r as a function of the intensity of the magnetic field H_o were examined, where R is the drift tube radius and r is the electron beam radius. The electron source was a pulsed electron-beam generator. Measurements of the emission current I, taken in the plane of a variable diameter diaphragm in the absence of the vacuum drift tube show that the electron beam and cathode diameters were equal at $H_o \geq 2000$ oe. When H_o was increased to 8000 oe the beam diameter, emission current, and the current density distribution with respect to the beam cross section remained invariable. The experimental electron current values were in good agreement with calculated limiting current values. The experimental data show that the transient stage of current settling for R/r = 2.4 and 3 apparently does not affect the value of the limiting current, when the ratio of the intrinsic magnetic field energy to the electron current kinetic energy is about 30%.

Mesyats, G. A., Yu. I. Bychkov, and V. V. Kremnev. Nanosecond pulsed electric discharges in a gas. UFN, no. 2, 1972, 201-228.

Recent research on gas discharges in the presence of electrical fields E higher than those of the streamer discharge mechanism is summarized

Since electron avalanches play a fundamental part in pulsed nanosecond discharge processes, consideration is initially given to the behavior of a solitary electron avalanche at a gas pressure equal to or greater than one atmosphere and in the presence of high electrical fields and high E/p ratios, where p = pressure. An evaluation is made of the effect of the electric field intensity on the number of photons leaving an avalanche at the moment of attaining the critical electron number N_k. It is noted that the number of photons decreases sharply as the intensity of the electrical field increases.

Proceeding from equations describing an electron avalanche with only a small number of electrons and a space charge field intensity much smaller than the external field intensity, the development of an electron avalanche is analyzed for the case of large amplification, with account taken of the electron cloud intrinsic field and diffusion.

Gas discharge gaps initiated by a small number of electrons are examined. In a discussion of the breakdown delay time and the current of the initiating electrons, three sources of cathode initiating electrons are indicated: a) electron emission from dielectric films and inclusions on the cathode surface; b) exoelectronic emission, and c) autoelectronic (field) emission. The latter emission source is the principal one in the supply of initiating electrons. Data are cited suggesting the existence of a field emission mechanism for initiating electrons during the pulsed breakdown of gas gaps in the presence of high electrical fields. The time of discharge formation is also discussed.

A pulsed gas discharge initiated by a large number of initial electrons is considered in terms of experimental results, the theory of avalanche current growth with multielectron charge initiation, and gas discharges in the presence of an intensive source of preliminary ionization.

Characteristics of a gas discharge in a super-high electrical field are also discussed. With a high electrical field, the field emission current from electrode surface micro- projections is amplified to such an extent that the projections explode, forming a plasma, and this plasma causes a further amplification of electron emission from the cathode. When $E>E_k$, the discharge plasma electrons begin to accelerate continuously. The value E_k is defined as the critical electron escape field.

It is shown that when $E/E_k > 2$, and $2\,E\,de/\epsilon > 100$ (where d is the gap length, and ϵ is the energy, ev) the electron energy at the anode, approaches $W \approx eEd$, which should cause X-radiation from the anode (cf. Ivanov, Ryukkert et al, April Monthly Report, p. 77). The relation of X-radiation intensity to E/p is analyzed, and data are given on the quantum energy of X-radiation in air at p = 80 torr and in helium at 400 torr measured by the foil method.

Kolomenskiy, A. A., M. S. Rabinovich, and Ya. B. Faynberg. Collective methods of particle acceleration in plasma and in heavy-current electron beams. UFN, v. 107, no. 2, 1972, 326-327.

Collective acceleration is suggested as the most promising way of obtaining a significant increase in the efficiency of electron beam accelerators. Collective methods of particle acceleration make it possible, in principle, to increase the specific energy by one or two orders of magnitude, and to attain gradients of up to 0.1 - 1 Gev per meter. Methods not tied to the use of relativistic electron rings are discussed. Research is being conducted at the Physicotechnical Institute, Academy of Sciences, Ukrainian SSR on such projects as ion acceleration in plasma density waves, the excitation of strong electrical fields during plasma-beam interaction, and the suppression of instabilities and control of plasma oscillations. A linear plasma betatron has been built at the Institute.

Plasma waves required for particle acceleration can be induced both by external superhigh-frequency oscillators in plasma waveguides, and in electron currents. Apparently the most promising will be the use of the interaction of intensive relativistic electron beams with plasma. A most important problem in the development of plasma accelerators lies in learning how to control instabilities and, if necessary to suppress them. Some methods for the control of plasma instabilities are mentioned. These include initial modulation of the electron currents with respect to density and velocity, and the use of an inhomogeneous plasma. Experiments have shown that the introduction at the system input of a signal comprising a very small portion of the intensity of the induced oscillations permits control to be exercised over the instability spectra.

Research is being conducted at the Lebedev Institute on the development of collective methods using relativistic electron beam scanning, autoacceleration, and ion acceleration in self-phased electron bunches as well as at the ionization front in a gas. It is pointed out that research results on collective methods of acceleration support the feasibility of developing high-capacity shf oscillators, and achieving efficient heating of plasma electrons and ions. The principal experimental basis for development of collective methods are high-current pulsed electron accelerators with energies on the order of a megavolt; much progress has recently been made in this direction.

Bogdankevich, L. S. and A. A. Rukhadze.
Problems of heavy current relativistic electron beams. UFN, v. 107, no. 2, 1972, 327-328.

The status of high power electron accelerator technology is reviewed. The most important problem in the development of high-capacity

heavy-current electron accelerators is cited as one of plasma heating by a high-current beam to thermonuclear temperatures and pulsed thermonuclear synthesis. The magnetic fields necessary for focusing a 10 Mev electron beam to an area of 0.3 cm^2 at a current of 10 ma and a pulse duration of about 3×10^{-8} sec are now technologically feasible. Heavy-current electron beams also offer great promise in the solution of the problem of collective ion acceleration and the development of heavy-particle accelerators in the 100-1000 Mev energy region at an average current of 1-10 a. The development of relativistic electron beams is also playing a decisive role in plasma electronics. The interaction of an ultrarelativistic monoenergetic electron beam with plasma yields electromagnetic waves such that at beam currents $I \approx 10$ ka and an energy of 30-50 Mev, it is feasible to construct pulsed emitters of centimeter and millimeter e-m waves with a relative bandwidth of about 10^{-2} - 10^{-3}.

Relativistic electron beams offer promise in solving the problem of phase transitions at high pressures. Pulsed pressures of several million bars have been created in a solid by relativistic beams at relatively low temperatures in the medium, and the possibility of obtaining metallic hydrogen in this manner was investigated by Bogdanovich and Rukhadze (ZhETF P, 13, 15, 1971). The value of heavy-current powerful electron beams as sources of controlled x-ray radiation is mentioned. Additional interesting possibilities suggested are ionospheric probes, and generation of artificial aurora effects; this would imply beams whose own magnetic field energy substantially exceeded particle kinetic energy.

Fursey, G. N., N. V. Yegorov, and S. P. Manokhin. Kinetic effects during field emission from silicon. FTT, no. 6, 1972, 1686-1690.

Characteristics of field emission current variation with time were investigated in p- and n- type silicon emitters during fast application of square voltage pulses. The Si specimens used were of various alloy grades (p-type with ρ = 14, 1000 and 2000 ohm cm; n-type with ρ = 10 ohm cm). The experiments were conducted on emitters whose surfaces had been cleaned by desorption in a strong electric field. Gas pressure during measurement was $5 \times 10^{-10} - 1 \times 10^{-9}$ torr. Voltage rise time was 2 μsec; peak value was steady within 1%. Voltage pulse duration could be continuously varied from 10 μsec to 100 msec.

Field emission current pulses were correlated to corresponding portions of the voltampere characteristic, which was obtained for all specimens in steady-state as well as pulsed regimes. It was observed that emission current appears with a lag relative to applied voltage in the linear portion of voltampere characteristic, and that pulse amplitude is independent of specimen illumination or temperature. A significant increase of current with time was noted in the saturation region of the v-a characteristics at a constant voltage; also, emission current reached maximum and then dropped to a steady-state value. This characteristic of current variation with time was noted on all investigated p-type silicon specimens; in contrast, no similar kinetic effects occurred in n-type specimens. The time lag of field emission current is attributed to the discrete alternation in space charge region during field application. The phenomonon of initial current maximum is associated with the generation of carriers by strong electric fields over the surface area of the specimen.

Zakharkin, R. Ya., and A. V. Pustogarov.
A one-megawatt hydrogen plasmatron. I-FZh,
v. 23, no. 1, 1972, 82-87.

An experimental investigation was made of a one-megawatt hydrogen plasmatron with a VL-10 lanthanum-coated rod, tungsten thermocathode 10 cm in diameter and a copper anode 38 mm in diameter, with magnetic twisting of the arc. In this device a hydrogen plasma with a mean-mass temperature above 4000° K and a satisfactory efficiency is obtained. The plasmatron was tested at arc current I_{arc} = 0.4-1.4 ka, hydrogen flow rate G = 5-15 g/sec, solenoid current I_{sol} = 20-30 amp, an external magnetic field of 0.2-0.4 kgs and arc chamber pressure P = 3-6 ata. The thermal efficiency of the plasmatron rose as the flow rate increased owing to decreased heat losses in the anode and increased voltage. Varying the magnetic field within the investigated range did not essentially affect the plasmatron output parameters (Fig. 1).

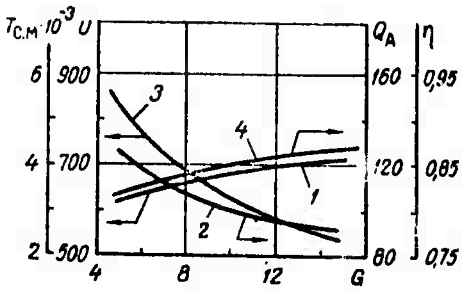

Fig. 1. Relationship of plasmatron parameters to hydrogen flow rate in g/sec (I_{sol} = 30 a, I_{arc} = 800 a): 1- voltage U; 2- heat loss to anode Q_A, kw; 3- mean-mass temperature T_{cm}, °K; 4- thermal efficiency η.

At I_{arc} = 800 a, G = 10 g/sec, P = 6 ata, and I_{sol} = 30 a, erosion of the tungsten thermocathode amounted to $\bar{G}$ = 5 x 10^{-6} g/coulomb and proceeded from the end surface. By increasing the plasmatron chamber pressure to 10-15 ata and the discharge current to 2-3 ka, it is considered feasible to increase the plasmatron power to 2-3 megawatts and heat 30-40 g of hydrogen to 3000-4000^{o}K at a thermal efficiency of 0.7-0.8. A sectional view of plasmatron construction is included.

Kirichenko, G. S., and V. G. Khmaruk.
Collisionless heating of ions in plasma by an ion beam. ZhETF, v. 63, no. 1(7), 1972, 107-111.

Plasma ion heating conditions were studied to determine the feasibilty of ion beam collisionless heating of plasma ions. A plasma-beam discharge in a homogeneous magnetic field was used. Ion beam injection into the plasma was accompanied by the excitation of a spectrum of ion-sonic oscillations. The developmental characteristics of the ion-sonic noise frequency spectrum are in qualitative agreement with conclusions of the theory of weak turbulence. It is shown that during ion beam excitation of low-frequency oscillations in a plasma-beam discharge, the beam interaction with a plasma of hot electrons can lead to heating of the ion component to a temperature comparable in value to the mean thermal energy of the electrons.

Probe measurements show that the ion heating is accompanied by a decrease of plasma density at the column axis. Under these conditions the ratio of the variable and constant components of the ion saturation current registered by the probe, i.e., the ion density oscillation amplitude, can attain values of 0.5-1. The effects of varying the magnetic field within 700-1600 oe on the ion beam vibration spectra and the degree of ion heating were negligible.

The experimental results support the feasibility of generating a hot electron and ion plasma by simultaneous longitudinal injection of electron and ion beams into the magnetic system. Fig. 1 shows the experimental apparatus.

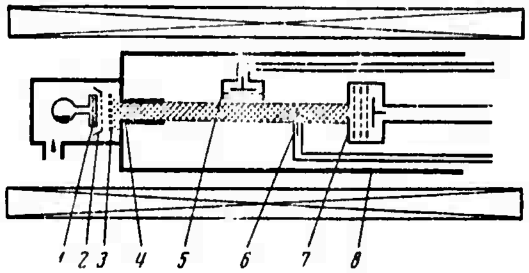

Fig. 1. Plasma ion heater. 1- tungsten emitter; 2- control grid; 3- cathode; 4- collimator; 5, 7- electrostatic analyzers; 6- probe; 8- vacuum chamber.

Vereshchagin, V L. Determination of the mass composition and energetic spectrum of a plasma jet in a pulse conical accelerator. I-FZh, v. 22, no. 6, 1972, 1096-1099.

Using a Thompson mass analyser, the author has determined the mass composition and energetic spectra of ionic components of a plasma jet, generated by a conical erosion-type accelerator. The experimental device is shown in Fig. 1 and a detailed description of it is given.

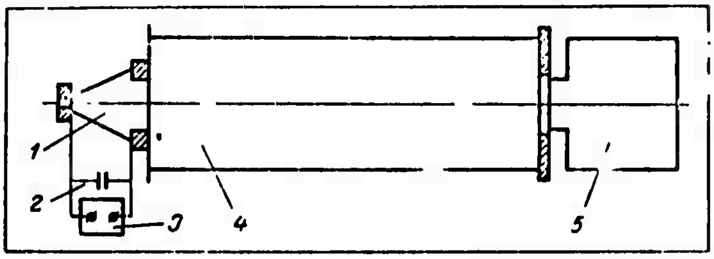

Fig. 1. Plasma jet analyzer. 1 - conical accelerator; 2 - energy storage; 3 - high-voltage charging device; 4 - vacuum system; 5 - Thompson mass spectrometer

The plasma was found to consist mainly of ions of insulator (teflon - 3 $(C_2F_2Cl)n$) decomposition products: Cl^+, F^+, C^+ and copper electrode material. In addition to single charged ions the plasma also contained multicharged ions (F^{2+}, C^{2+}) although in negligible amounts. The plasma ion component was found to depend upon parameters of the electric circuit, principally circuit inductance L_o and battery energy Q_o. For a given Q_o, increase of L_o decreased the number of erosion ions, whereas an increase in Q_o at constant L_o caused an increase in ion population of all types. The temperature of plasma electrons T_e and its variations for plasma propagation in the vacuum chamber were also determined. T_e was found to depend very little on circuit parameters L_o and Q_o. The value of T_e varied from 2 to 3.5 ev only for a wide range of L_o and Q_o. The maximum ion density was found to reach $\sim 10^{15}/cm^3$.

Belikov, A. G., V. P. Goncharenko, D. K. Goncharenko, and N. T. Derepovskiy. Separation of plasma bunches, moving at an angle to the axis of coaxial source. ZhTF, no. 6, 1972, 1325-1327.

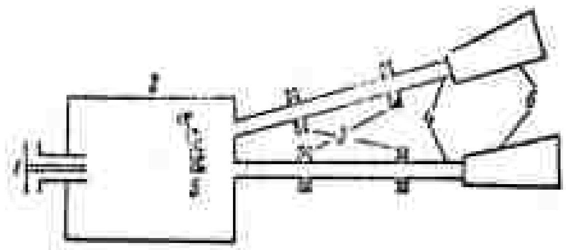

Fig. 1. Plasmoid generator. 1- coaxial source, 2- vacuum chamber, 3- diamagnetic probes, 4- glass plasma guides, 5- calorimeters, 6- Thompson mass spectrometer

A system for developing plasmoids has been devised, as shown in Fig. 1. Measurements of diamagnetic signals and mass spectra showed that a plasmoid moves in the angled plasma guide, with a velocity $(8-9)\cdot 10^7$ cm/sec and a density exceeding $10^{12}/cm^3$. This plasmoid was noted at any polarity of the center electrode during the first half cycle of discharge in the source. Fig. 2 shows signals of diamagnetic probes, placed in the main axial and angled plasma guides. It is seen that both signals start nearly at the same time, demonstrating that plasma velocity moving along the axis does not differ significantly from that moving at an angle to the source axis. The width of the diamagnetic probe signals depends on the polarity of central electrode potential during the first half cycle of the

Fig. 2. Diamagnetic probe signals. Lower curve - axial probe signal upper curve - lateral probe signal Battery source voltage 18 kv, time lag - 450 μsec, Central electrode is + at the beginning of discharge.

discharge in source, signals at - v_e polarity being narrower than at + v_e; this holds true for a plasmoid moving in the axial as well as in the angled guide. The energetic spectrum of hydrogen ions for both plasmoids were similar, although energy density of the axial plasmoid was about 5 times that of the angled plasmoid. It follows that the angled plasmoid has all properties of the axial one, except a smaller number of particles. This similarity makes it possible to obtain several plasma guides at an angle to the source axis, thus obtaining several similar simultaneous plasmoids phased in time.

Kvartskhava, I. F., Yu. V. Matveyev, and N. G. Reshetnyak. <u>The mechanism of charged particle acceleration in a dynamic zeta-pinch.</u> ZhETF P, v. 15, no. 10, 1972, 619-622.

Experiments were carried out to verify the significance of discharge reignition in charged particle acceleration in a dynamic zeta-pinch, leading to the generation of X-ray and neutron irradiation. The experiments were conducted in the device shown in Fig. 1, with parameters

of C = 48 μf and v_o, v_o = 20-25 kv. The chamber internal diameter was 20 cm, and its length was 50 cm. Discharges were investigated in hydrogen, deuterium, helium, air and argon at pressures of 5 to 2 x 10^{-2} torr. The experimental results agreed with the concept of discharge reignition in the charged particle acceleration. The authors point out that this mechanism can also develop in other pulsed dischargers such as non-cylindrical pinches and plasma focuses.

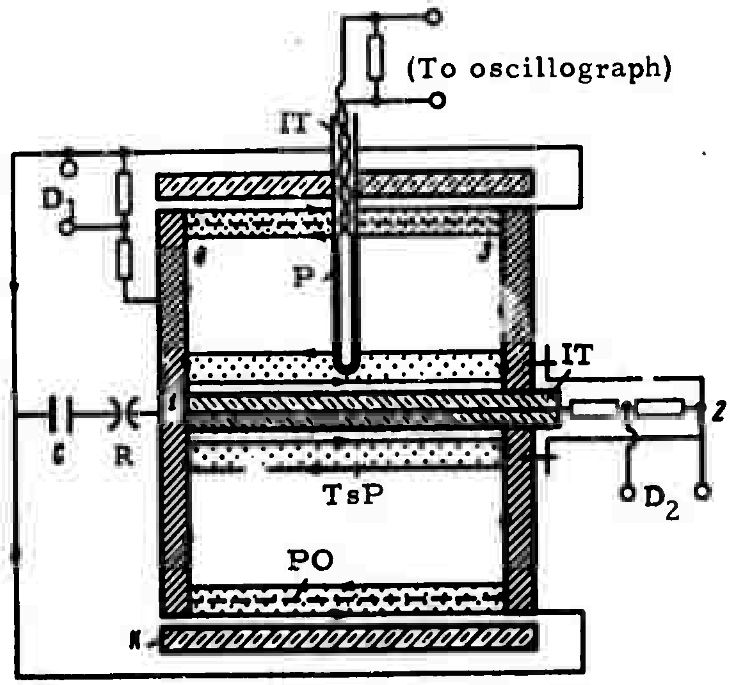

Fig. 1. Experimental device. D_1, D_2 - voltage dividers; P- loop; R - discharger; TsP- central pinch; PO- plasma boundary layer; IT - insulated tube; K- chamber wall. The arrows show current flow direction.

Borisov, D. G., A. I. Gryzlov, V. I. Muntyan, V. M. Nikolayev, I. A. Prudnikov, and Yu. P. Shchepin. Linear accelerator of charged particles. Author's certificate, USSR no. 300135, published Sept. 3, 1971, 2 p.

A patent for a linear charged particle accelerator is described, comprising an accelerating system, a charged particle source, generators for the particle source and the accelerating system, and a synchronizer. A device for varying the particle current is introduced in the accelerator between the synchronizer and the particle source control electrode. This device consists of a ring scaling circuit, stepped pulse generators, and a terminal repeater. A diagram of the accelerator is presented in Fig. 1.

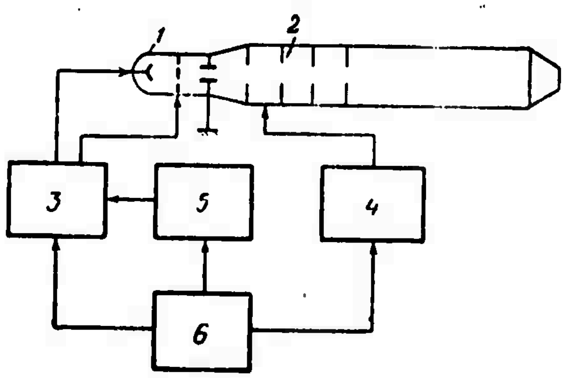

Fig. 1. Block diagram of linear particle accelerator.

1- charged particle source;
2- accelerating system (iris waveguide);
3- generator (electron source);
4- generator (accelerating system);
5- unit for particle current variation;
6- synchronizer.

Averin, V. G., A. I. Karchevskiy, and G. V. Yurkin. Stimulated emission with pulsed electron beam pumping, formed in a direct discharge. ZhETF, v. 63, no. 1, 1972, 85-91.

Stimulated laser emission was investigated in an argon plasma with powerful pulsed electron beam pumping in a direct discharge. Glass vacuum chambers, 4 and 10 cm in diameter and 1.5 m long were divided into one region in which the powerful electron beam was formed and served as the electron gun (A), and another filled with cold preliminary plasma (B). When a high-current discharge was generated between the electrodes and current instability in the gas-discharge region (A) occurred, a powerful electric beam was formed which passed through and interacted with the cold plasma region (B). Heating of the plasma electron component was followed by excitation of the ion component and formation of conditions for stimulated emission.

It is shown experimentally that stimulated argon-ion emission originates during the collective interaction of a pulsed electron beam with a capacity of 100 mw in a high-current direct discharge, with a prepared argon plasma of a density $n_o = (3 \cdot 5) \times 10^{13}$ cm^{-3}. Generation occurs in the visible spectrum range (single ionized argon Ar II, $\lambda = 4765$ Å, $\lambda = 4880$ Å) and in the ultraviolet range (doubly ionized Ar III, $\lambda = 3511$ Å, $\lambda = 3638$ Å); the generation power at the Ar II transition is 1 kw.

Conditions for the generation begin at the moment of electron beam formation in the direct discharge, and the subsequent collective beam interaction with the argon plasma. Generation takes place in a specific range of argon pressure (preliminary-plasma density). This is apparently linked with the efficiency of the beam-plasma interaction, which is determined by the energy spectrum of the forming electron beam in a direct discharge.

Interaction of the powerful electron beam, formed in the direct discharge, with the preliminary argon plasma results in the excitation of laser levels by both the direct (Ar II, $\lambda = 4765\ \mathring{A}$) and the stepwise processes (Ar II, $\lambda = 4880\ \mathring{A}$).

Lisin, V. N., N. N. Shtuchkin, and O. A. Kiselev. High voltage device for producing electron beams. Author's certificate, USSR, no. 285131, published May 31, 1971.

This patent describes a high voltage electron beam device which consists of a pulsed autotransformer with a toroidal care, mounted on vertical ceramic insulators. The autotransformer winding has an external primary winding and is in the form of a rigid spiral surrounding the core. The internal high voltage winding is attached to the core. Ceramic insulators wound through openings in the remaining loops serve as vacuum windings of the field-emission accelerator tubes. The compact device has the capability of generating a series of electron beams. Other advantages of the device are:

1. The parameters of pulsed electron current in the integrated pulsed autotransformer system can be regulated from the primary side of the winding, when as with other transformer types, the alternating voltage is converted and pulsed electron currents of the required duration and form are generated using a complex control system at a voltage on the order of 1-3 mv.

2. The inclusion of a pulsed autotransformer with a closed magnetic circuit permits increases in the average beam power peak value.

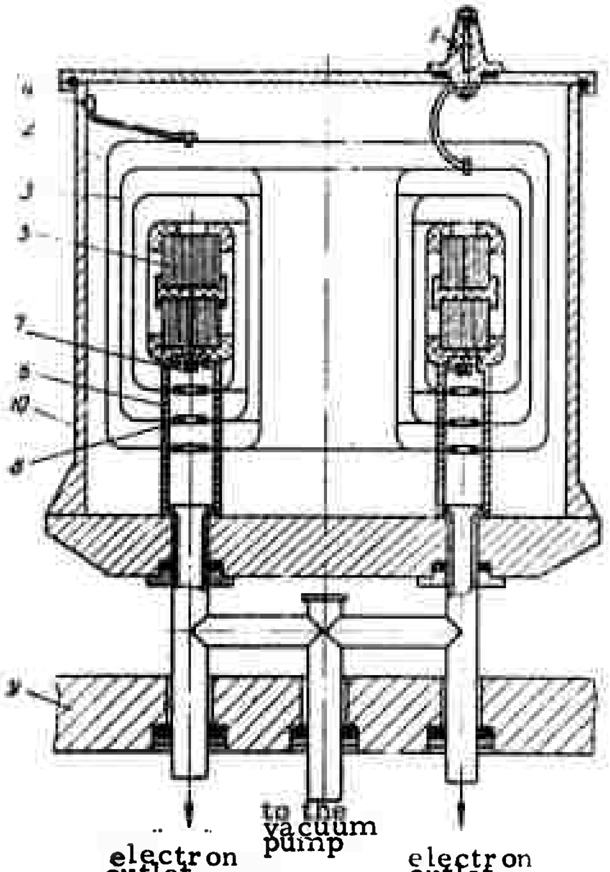

Fig. 1

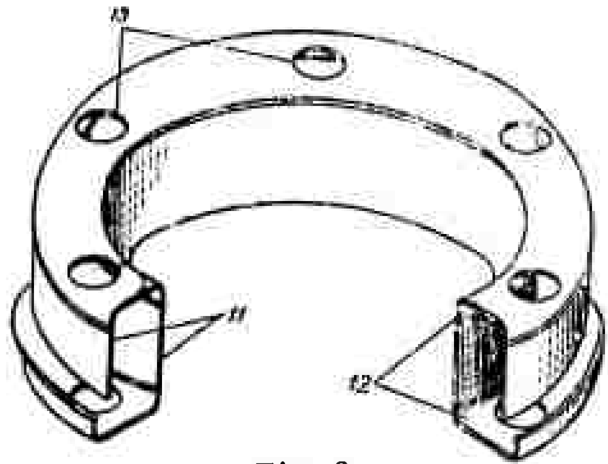

Fig. 2

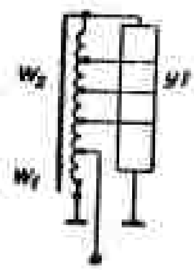

Fig. 3

Fig. 1 - Sketch of the integrated system; Fig. 2 - Transformer; Fig. 3 - Pulsed autotransformer schematic.

1 - insulator; 2 - primary winding; 3 - secondary winding; 4 - ground; 5 - sectional closed core; 6 - accelerator tube; 7 - field emission cathode; 8 - intermediate electrodes; 9 - radiation shielding; 10 - tank; 11 - cylinders; 12 - end plates; 13 - apertures.

Grigor'yev, Yu. N., S. O. Grishayev, and M. M. Naugol'nyy. Effect of the collective interaction of particles on linear dimensions of electron bunches in an accumulator. UFZh, v. 16, no. 10, 1971, 1729-1732. (RZhElektr, 2/72, no. 2A420) (Translation)

The effect of the force of collective interaction on the phase motion of relativistic electrons in a storage ring is considered. It is shown that the decrement of synchrotron oscillations decreases and the linear dimensions of the electron bunch increases with an increase in accumulated particles. Theoretical and experimental data on the effect of increasing the linear dimensions of the bunch are compared.

B. Recent Selections

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An'shakov, A. S., V. V. Kozlov, and M. I. Sazonov. Study of a free plasma jet. IN: 10th Int. Conf. Phenomena of Ioniz. Gases, Oxford, 1971, 247. (RZhMekh, 9/72, no. 9B187)

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5. Material Science

A. Abstracts

Kachanov, M. L. On a continuity theory for crack media. MTT, no. 2, 1972, 54-59.

In a further development of the continuity theory introduced by the author and A. A. Vakulenko [MTT, no. 4, 1971, 159-166], the crack density volumetric tensor T_α is described as the sum of the normal fracture density tensor $T_\alpha^{(n)}$ and the tangential fracture density tensor $T_\alpha^{(\tau)}$. The invariant sp T_α of T_α, in the absence of elastic strain, is equated to the crack void factor $k = \mathrm{sp}\, T_\alpha^{(n)}$, a characteristic of body density changes produced by crack propagation. Several approximations of the stress strain equation are introduced for specific applications. The crack density reversible component T_α^{e} can be disregarded for a rock massif or the base of a massive structure under a prolonged strain with a large spherical component. The elastic state is described in this approximatio by Hooke's law for an anisotropic medium with elastic moduli dependent on T_α. In continuity theory, local anisotropy of a fissured medium is defined by the T_α tensor and nine functions $\omega_1, \omega_2, \eta_1 \ldots \eta_7$ which are the material characteristics. The elasticity of many media, e.g. a rock massif, depends solely on crack void distribution. Since this distribution can be described by the normal component $T_\alpha^{(n)}$ alone, any normal fissility can be represented in continuity theory by three reciprocally orthogonal planes. Elastic anisotropy due to fissility is described in this case by an orthotropic expression for system enthalpy h. This expression shows that the body is orthotropic at any point; and the principal orthotropic directions are coincident with the main axes of $T_\alpha^{(n)}$. The $\omega_1, \omega_2, \eta_1, \ldots, \eta_7$ functions in the h expression can be experimentally determined by measuring the elastic moduli and the fracture intensity β_i along the i plane.

Approximations of continuity theory are discussed for significant types of layered and small fissility. For layered fissility, the cracks are approximated by parallel planes and $T_\alpha^{(n)} = knn$. The simplified h expression shows that this fissility medium is transversally isotropic at any point. In the medium of small fissility, $|T_\alpha| \leq 1$, ω_1, ω_2, $\eta_1, \ldots, \eta_7$ are constants. Such a medium can be described, in a further approximation of h, by only four elastic constants: G_o, ν_o, η_2, and η_5, where G_o and ν_o are the shear modulus and Poisson's ratio of the nonfractured medium, and η_2, η_5 can be determined in two experiments.

Gol'dshteyn, R. V., and L. N. Savova. Determination of opening and stress intensity factors for smooth curvilinear cracks in an elastic plane. MTT, no. 2, 1972, 69-78.

An exact numerical solution is presented to the problem of an elastic plane with a smooth curvilinear slit L in the form of an arc or a line segment conjugate with an arc under various loading modes. The numerical solution was attempted because an exact solution for an arbitrary curve under an arbitrary load was not possible using an earlier set of integral equations with a Cauchy-type kernel. The method introduced by Kalandiya (DAN SSSR, v. 125, 1959, no. 4) was used in the present analysis to solve a set of singular integral equations in parametric form $x = x(t)$ $y = y(t)$, where $-1 \leq t \leq 1$. Normal $\sigma_n(t)$ and tangential $\sigma_t(t)$ loads are applied to the edges of L. The method consists of reducing the parametric integral equations to a set of linear algebraic equations with a condition of single-value displacements b_k^ρ along the L contour. The algebraic equations are solved for $b_k^\rho{}_\nu = b_k^\rho(t_\nu)$ where $k = x$, y and ν is the Poisson ratio. The $b_{k\nu}^\rho$ values at the L tips $[-1, 1]$ are used to calculate the ultimate tensile N_n and shearing N_t stress intensity factors for varying central angle θ and crack parameters C_1 and t_1. Normal and tangential crack openings are also

calculated using the formula

$$u_i(t) = -\int_0^{\nu} b_i^*(\cos\theta)\,d\theta \tag{1}$$

where $t = \cos\nu$.

The N_n and N_t exact values for the arc-shaped crack with $\theta \leq 15^\circ$ differed by 11-16% from the first approximation values for the cases of uniform extension at infinity along the arc symmetry axis and at a 30° angle to the symmetry axis, and for extension to infinity along the symmetry axis under a load varied linearly and normally to the axis. Analogous N_n and N_t data for the weakly curved crack with $\theta \leq 20^\circ$ differed by only 10%. For a weakly curved crack, unifomly extended to infinity, the reduced N_i^* ($i = n, t$) at the left tip of L (the end of the line segment) differed by $\leq$ 10% from N_i^{*r} of a rectilinear L crack when the line segment length was at least 1/2 of the total L ($t_1 > 0$). When this last condition is not satisfied, N_i^* is in good agreement with N_i^{*r} only at $\theta < 30^\circ$. The N_i^* at the right tip of L (the end of the curvilinear segment), uniformly extended at infinity in the normal direction, agrees with the N_i^{*r} value at small θ and large $\rho = R/\ell$, where ℓ is the crack half-length.

Molchanov, A. Ye., and L. V. Nikitin. <u>Dynamics of crack longitudinal shift following stability loss</u>. MTT, no. 2, 1972, 60-66.

Unstable dynamic crack propagation in a body under a static load is analyzed on the basis of Kostrov's theory. The Griffith problem is solved for an infinite elastic medium with crack tips at the points $x = \pm l_0$.

and a y axis normal to the crack surface. The applied constant forces parallel to the z axis cause an axial shift. Only the τ_{xz} and τ_{yz} stress components are acting on the crack. A dynamic process begins when the load exceeds a limit

$$\tau_* = K_0/\sqrt{l_0} \tag{1}$$

where K_o is the limiting stress intensity factor. In this case, static equilibrium is impossible at any crack length $\geq l_o$ and the effect of the $\gamma/\gamma_o = \alpha^2$ dynamic to static energy ratio on crack behavior becomes significant. At $0<\alpha<0.8758$, the crack tip motion is described by the equation

$$\dot{l} = b\frac{l_*^2 - 1}{l_*^2 + 1}, \qquad l(0) = l_0 \tag{2}$$

where b is the transverse wave velocity and

$$l_*(l, l_0) = \frac{2}{\pi\alpha}\sqrt{\frac{2l_0}{l + l_0}}\left[\left(\frac{l}{l_0} + 1\right)E\left(\sqrt{\frac{l - l_0}{l + l_0}}\right) - K\left(\sqrt{\frac{l - l_0}{l + l_0}}\right)\right], \quad \alpha = \sqrt{\frac{\gamma}{\gamma_0}} \; ; \tag{3}$$

$K(\varphi)$ and $E(\varphi)$ in (3) are elliptic integrals of the first and second kind, respectively.

The asymptotic solution of (2) for bt indicates that, at $0<\alpha<0.8758$, the perturbation wave from one tip does not affect the motion of the other tip. At $0.8758<\alpha<1$, the solution of (2) is applicable before the wave from one tip reaches the other, at times $bt < x + l_0$. The solution of (2) at $\alpha = 1$ and a critical load is unstable and the crack sets in motion at any perturbation which shifts it into the instability region above the moving

equilibrium curve. This occurs when the crack is overloaded or its tip is undercut. In the period $x + bt_1 + l(t_1) > bt > x + l_0$, where t_1 is the time when a wave from one tip reaches the other tip (the first diffraction of the wave), the motion of a tip is described by

$$l(t) = l(t_1) + \frac{l_0^4 - 1}{l_0^4 + 1} b(t - t_1) + \frac{32(1 - \alpha^4) l_0^2}{3\pi a \sqrt{l(t_1)}\, l_0 (l_0^4 + 1)^{3/2}} b^{3/2} (t - t_1)^{3/2} + O[(t - t_1)^2] \tag{4}$$

where l_0 is expressed by (3) at $l = l(t_1)$. The solution of (4) shows that the crack motion is smoothly accelerated after the wave reaches the other tip.

The pop-in effect problem is also analyzed. This effect sometimes appears during quasistatic stable crack propagation from a concentrated load applied in the middle of the crack surface. The equations (2) and (4) are also applicable to this case. Solution of (2) and (4) at $\alpha<1$ are given.

Deryabina, V. I., L. A. Glikman, and V. P. Teodorovich. Determining mechanical properties of steel based on short duration separation in hydrogen at high temperatures and pressures. F-KhMM, no. 3, 1972, 71-74.

Changes in the mechanical properties of carbon and alloy steels during short-term tensile testing in hydrogen at 20-800° C and 50-200 kg/cm^2 were investigated. An attachment designed for the R-5 universal tensile

testing machine, and a procedure developed for short-term tensile testing of metals to determine $\sigma_{0.2}$, σ_b, δ, and φ in hydrogen were used. Test specimens were either cylindrical with threaded heads or flat. The deformation rate was constant at about 2.8% per minute.

The effects of temperature on the mechanical properties of carbon steel (steel 20) cylindrical specimens were tested at a hydrogen pressure of 100 kg/cm^2 and at 25, 320, 400, 500, and 600° C. The tests show that the mechanical properties did not vary to 300° C; at 400° C some strengthening was observed, with a tendency towards plasticity. At 500 and 600° C, a perceptible decrease of strength and plasticity was observed. The influence of hydrogen pressure on the mechanical properties of steel 20 was studied at 25, 400, and 500° C and 50, 100, and 200 kg/cm^2, after 30 minutes of preliminary exposure to hydrogen. At 25° C, the steel 20 was not affected by hydrogen pressure. At 400 and 500° C, the properties changed at a rate approximately proportional to the square root of the hydrogen pressure.

High-alloy, low-carbon steels were tested at high temperatures and high hydrogen pressures, after preliminary periods of hydrogen exposure ranging from 30 minutes to 20 hours. The mechanical properties of these steels after short-term rupture in hydrogen did not differ from those at the corresponding temperatures in air. Prolonged testing (10-20 hours) in hydrogen resulted in an insignificant strength increase and a plasticity decrease, evidently from the physical effects of the absorbed hydrogen. The effects of steel 20 exposure in hydrogen for 0.5 to 43 hours at 500° C and 200 kg/cm^2 prior to tensile testing under the same conditions were also examined. The mechanical properties of the steel 20 specimens were characterized by a greater degree of decreased strength and plasticity than for the tensile tests conducted in air after cooling.

Brazhnev, V. V., and P. O. Pashkov.
Effect of shock wave structure on results of shock loading of metals. IN: Metallovedeniye i prochnost' materialov, Volgograd, v. 3, 1971, 226-233. (RZhMekh, 6/72, no. 6V1022)(Translation)

Shock loading of metals in a plane shock-wave generator was studied at amplitudes to 1 Mbar. Part of the specimen surface was covered by a screen(0.4 mm thick aluminum foil). Armco iron, copper, and titanium specimens were studied. It was assumed that the portion of the specimen under the screen was loaded repeatedly, and the portion free of the screen was loaded by a single wave. The effects of repeated and single compression tests are compared.

Brazhnev, V. V., and P. O. Pashkov.
Characteristics of shock wave hardening of copper, titanium and nickel, at pressures to 1200 kbar. IN: Sbornik. Metallovedeniye i prochnost' materialov. Volgograd, v. 3, 1971, 234-240. (RZhMekh, 6/72, no. 6V1027) (Translation)

An attempt was made to estimate the effect of the surface curvature of shocks at the moment of collision on the hardening parameters of copper, titanium and nickel at pressures to 1200 kbar. According to the authors, this could lead to the formation of convergent or divergent shock waves in test specimens.

Kislykh, V. V., and Kh. A. Rakhmatulin. Dual-chamber adiabatic compression assembly. TVT, no. 2, 1972, 400-404.

The dual-chamber adiabatic compression assembly described differs from ordinary types by the addition of a large forechamber, serving as an accumulator of the low-temperature working gas. This forechamber is connected via an adjustable throttle to the smaller conventional forechamber (Fig. 1).

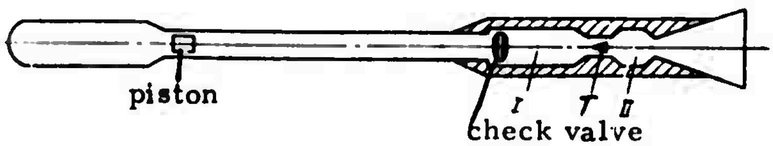

Fig. 1. Dual-chamber adiabatic compressor
I- large forechamber, II- small forechamber,
T- adjustable throttle.

A quantitative analysis is given of the work of the compression assembly using conventional N_2 gases, as well as N_2O gases capable of exothermal reactions. It is shown that, compared to single-chamber assemblies, the duration of the experiment can be increased by a factor of 10-100 using dual-chamber assemblies; in addition, the forechamber maximun gas temperature can be increased from 2000 to 3000° K (for diatomic gases), and the forechamber gas pressure may reach values of 10 to 3500 atm at any law governing changes in time.

The dual-chamber adiabatic compressor characteristics allow a substantial expansion in the range of reproducible Mach numbers with given dimensions of the assembly, or reductions in the dimensions of the adiabatic compression assembly in accordance with the duration of experimental tests.

Exploded benzene ring. Khimiya i zhizn', no. 6, 1972, 27.

Pressure tests are briefly mentioned in which carbon-carbon bonds in a benzene ring were broken and the benzene was converted into a polymer of a high molecular weight at the Institute of Chemical Physics, AS SSSR. A solid brown polymer was obtained in this way by compressing liquid benzene at 85,000 atm. The pressure was generated by exploding a heavy charge in a tungsten carbide, ultra-high strength anvil. The solid polymer was infusible and insoluble in concentrated sulfuric acid or organic solvents. IR spectroscopy and ESR studies reveal that the polymer molecule was formed by exploding the benzene ring and linking together the broken rings.

Sergeyev, V. L. Heat transfer characteristics during the initial stage of heating solids by high-temperature gas flow. IAN BSSR, Fiz-energ, no. 2, 1972, 113-118.

Heat flux q_k during the initial heating of a blunt body at the stagnation point was measured, based on a semi-infinite body method which was developed earlier on the assumption of a constant q_k within incremental heating periods. In the experiments, copper cylinders protected laterally by an insulating bushing served as semi-infinite blunt body models. Bushings with hemispherical and flat noses were used in conjunction with 3 and 10 mm dia. cylinders, respectively. The experimental models, 15-100 mm in length δ, were heated by a nitrogen plasma jet from an arc heater nozzle located 25 mm below the model. The average stationary heat flux was 1.27-1.4 kw/cm^2. Temperature was recorded at 5 mm and δ distances from the heated end by a multi-beam oscilloscope. The semi-infinite body model was realized within the 0.6-3sec interval from the beginning of heating until a temperature increase was detected at the rear end (opposite to the heater) of the model. Experimental temperature

t versus time τ plots were used to calculate q within the incremental time periods $\Delta\tau$ = 0.1-0.4 sec (Fig. 1). The optimum x and $\Delta\tau$ were 5 mm and 0.2-0.4 sec., respectively.

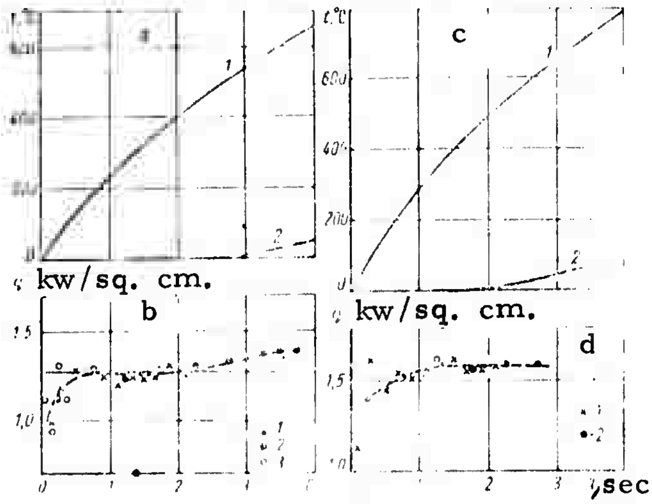

Fig. 1. Experimental heating data: a, c- specimen t versus τ: 1- x = 5 mm, 2- x = δ; b, d- nonstationary q versus τ: 1- $\Delta\tau$ = 0.2, 2-0.4,3- 0.1 sec., 4- exponential method. δ = 100 mm for a and b and 50 mm for c and d.

The data show that surface q increases to a constant quasistationary value which agrees fairly well with the q measured by the exponential method. At constant gas flow parameters, the relative nonstationary heat flux

$$\frac{q_n}{q_{st}} \quad 1 \quad 0,6 \ldots \text{[illegible]} \qquad (1)$$

during the initial heating stage beginning at 0.05 sec. is 30-70% of its quasistationary value. The accuracy of the q_n/q_{st} determination from (1) is at least 8%. It is concluded: a) the semi-infinite body method is applicable at $\Delta Fo_x > 0.5$; and b) calculation methods developed for the stationary heating regime are not applicable to initial stage heating.

Fridlender, L. A., and V. S. Neshpor. Directional dependence of high temperature conductivity of crystal-oriented pyrolytic graphite. TVT, no. 2, 1972, 313-317.

The phase method was used to investigate the vector effect of the thermal conductivity of alpha-specimens of pyrolytic graphite with a density of 2.26 g/cm^3. Obtained by chemical gas-phase precipitation at 2400° C, this graphite has a high degree of predominant orientation of the basal planes. The phase method is based upon electronic measurement of the phase difference between a periodic heat flux and the temperature fluctuations. The specimens were cut from pyrolytic-graphite plates about 12 mm thick, at various angles θ between directions normal to the plane of the specimen and the precipitation surface. The normal to the specimen surface coincided with the direction of the heat flux. The specimens were about 0.120 to 0.450 mm thick.

Results show that the thermal conductivity of pyrolytic graphite is essentially anisotropic. The conductivity anisotropy is caused by the strong elastic anisotropy of the graphite crystal lattice and the corresponding anisotropy of atomic oscillation frequencies in the direction of the a- and c-axes. For comparison, the a-axis was investigated in a direction normal to the precipitation surface in a thermomechanically treated pyrolytic graphite specimen which had a more refined texture. The thermal conductivity of pyrolytic graphite in the direction of the a- and c-axes was calculated as a function of temperature.

Golovina, Ye. S., and L. L. Kotova. Carbon sublimation in a flow. TVT, v. 10, no. 2, 1972, 368-380.

An experimental and theoretical study was made of graphite sublimation in Ar flow at velocities ω = 0.5 to 30 m/sec and temperatures in the 2,800-3,500° K range under atmospheric pressure. Selection of the broad temperature and flow rate ranges was prompted by the importance of finding ways to increase graphite ablation resistance in gas flow at high temperature, pressure, and velocity. The specific sublimation rate g_s of spherical (diameter 12 mm) 'TM-4 industrial graphite samples was measured in a high-pressure chamber. The experimental apparatus is described. The surface temperature gradient of the induction-heated sample was ≤ 100° at 3,000° C. Temperature the samples was maintained within ± 5°. Weight was continuously recorded by an analytical balance with automatic vertical shift compensation of the sample position. The sample experimental radial density distribution after sublimation and micrographs of the sublimed surface suggest that sublimation occurs in the porous material simultaneously with surface sublimation. The experimental g_s data (Fig. 1)

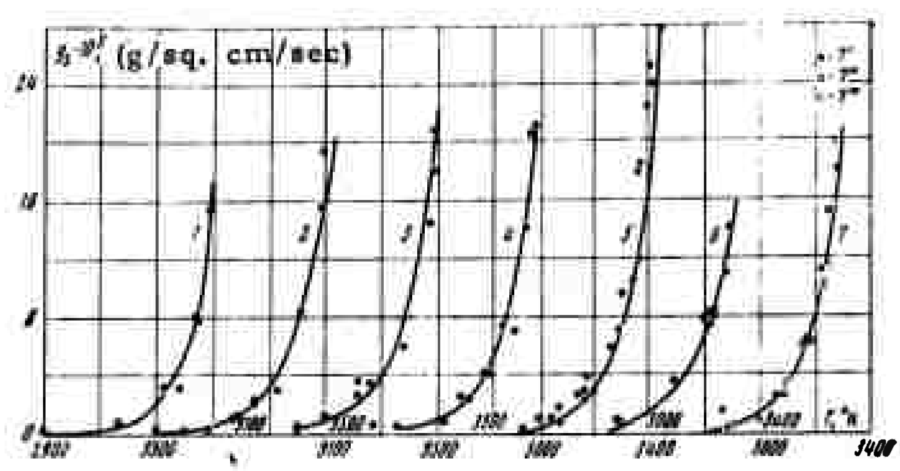

Fig. 1. Carbon sublimation rate versus temperature at 1 atm pressure and gas flow rates (m/sec) of: 1- 0.5, 2- 1.0, 3- 2.5, 4- 4, 5- 8, 6- 12, 7'- 20, 7''- 25, and 7'''- 30.

show that sublimation is a diffusion-controlled process at $\omega = 0.5$-12.5 m/sec and at $\omega \geq 20$ m/sec it is a kinetics-controlled process with an activation energy = 170 kcal/mol. The theoretically derived formula

$$g_s = \frac{c_s}{1/\sqrt{D'\nu\alpha'} + 1\Big/\frac{D}{d}\mathrm{Nu}_{\text{диф}}}. \tag{1}$$

(where c_s is the concentration of saturated vapor, D' and α' are the effective diffusion and sublimation coefficients, $\nu = (RT_\omega/2\pi\bar{M})^{1/2}$, D is the vapor diffusion coefficient, and d is the diameter of a sublimed particle) establishes the sublimation dependence on both kinetic and hydrodynamic factors. These factors were calculated from the experimental data, and g_s was calculated from (1) and the data plotted in Fig. 1 using continuous lines. The plots of theoretica g_s versus ω reveal that the boundary between the diffusion-and kinetics-controlled regions shifts toward higher ω with increased temperature.

Ivanov, V. V., and I. L. Dunin. Investigation of boundary layer heat transfer, taking surface radiation into account. IAN Energ, no. 2, 1972, 167-172.

A new mathematical method is applied to the solution of the nonlinear problem of heat transfer, at a high Mach number M, through the laminar boundary layer of a transparent compressible gas. The method is introduced to fulfill the need in supersonic flight and missile technology of reliable and practical calculations of heat transfer from the simultaneous effects of convection and radiation. The problem is formulated using a physical model of free-stream gas flow at a constant temperature T_∞ and

velocity V_∞ around a thin plate of ℓ length. Temperature profiles $\theta\,(x/\ell)$ at the plate surface and $\theta(\tau)$ in the boundary layer are calculated from

$$Z(0) = \frac{1}{p}\ln\left(1 + \frac{p\,Sk_x}{0{,}332\sqrt[3]{Pr}\sqrt{Re_x}}\right) + Z_\infty \qquad (1)$$

and

$$W_x(\tau) = W_\infty\left[1 - \left(1 - 0{,}332\sqrt[3]{Pr}\,\frac{\sqrt{Re_x}}{Sk_x}\right)^{-1} f(\tau)\right] \qquad (2)$$

where Pr, Re_x, and Sk_x are Prandtl, Reynolds, and Stark radiation numbers, τ is a Blasius variable and p is the correction parameter given by

$$p = 4\left(\frac{\theta_\infty + \theta_{x=l}}{2}\right)^3. \qquad (3)$$

θ_∞ and $\theta_{x=l}$ in (3) are dimensionless temperatures in the free-stream and at the end surface. The (1) and (2) formulas were derived from the Blasius flow and thermodynamic equations by linearization using linear transformation

$$Z(\tau) = \frac{\ln W(\tau)}{-p} = \frac{1}{2}\left[\operatorname{Arcth}\theta(\tau) + \operatorname{arctg}\theta(\tau)\right]. \qquad (4)$$

The simplicity and high accuracy of the temperature calculation are the significant advantages of the cited method, as shown by the estimates of the upper and lower bounds of W. Numerical values of $\theta(x/\ell)$ and $\theta(\tau)$ obtained by the method for a particular case differ by no more than 2.5% from the more reliable values of Sparrow and Lin(International Journal of Heat and Mass Transfer, v. 8, no. 3, 1965).

Druker, I. G., and L. Ya. Treyer. Flow calculation in the vicinity of the stagnation point during liquid coolant feed. ZhPMTF, no. 2, 1972, 44-48.

An exact solution is presented to the problem of thermal insulation of a hypersonic blunt body by forced feeding of a liquid coolant through the body surface. In contrast to previous studies, allowance was made for the gas layer interaction with the liquid film adjacent to the surface. The mathematical description of the artificial liquid film (as opposed to the natural liquid film formed by melting) is based on the assumptions that the coolant consumption $(\rho v)_w$ at the liquid-body interface is an independent parameter and the liquid film thickness δ is finite. Gas flow is described by hypersonic boundary layer equations near the stagnation point and liquid flow by noncompressible boundary layer equations. The equations of state, motion, energy, and gaseous components diffusion describe the relationship of boundary layer "frozen" gas flow to outer boundary parameters. The equations of motion and energy describe film liquid flow using the dimensionless variables ν and ζ related to the gas-liquid interface. At the gas layer outer boundary, the boundary conditions are calculated from the flow around the body. The boundary conditions at the gas-liquid interface express continuity of tangential velocity, temperature, tangential stresses, transverse mass and energy fluxes, and conservation of the components in the absence of chemical reactions (constant concentrations At the liquid-solid interface ($\nu = \delta$), the boundary conditions are

$$\Psi_\nu = 0, \quad t = T_\nu T_\nu \qquad (1)$$

where T_ν is the solid wall temperature and Ψ_ν is the longitudinal velocity component.

The finite difference flow equations were solved by the method of successive approximations. Linear profiles of concentrations and temperature and the quadratic dependence of the flow functions were taken as the zero-th order approximation. The set of difference equations was solved by the method of successive calculations, and the next order approximation was derived using boundary conditions.

Calculation results are presented for oxygen flow around a 1 m water-cooled sphere at a pressure P_e = 1 atm., T_v = 373° K, T_e = 6,500°K and U_{es} = 2,200/sec. The gas layer was assumed to contain O, H_2O, and O_2. The body surface coolant was at boiling temperature. The calculations indicate that underheated water is unsuitable for thermal insulation because the film spreads before the evaporation effect becomes significant. It is shown that δ variations in the 0.01-2 range substantially affect the relative amount of evaporated coolant (Fig. 1). This amount approaches 100% at

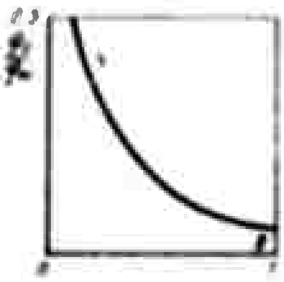

Fig. 1. Relative amount of evaporated coolant versus liquid film thickness.

δ→O, i.e. all the coolant supplied is evaporated. In this extreme case, the coolant consumption limit is a finite value (Fig. 2).

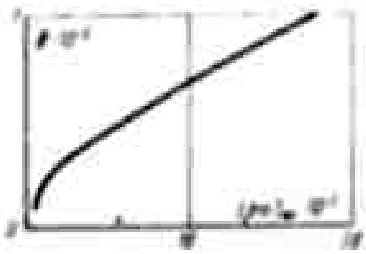

Fig. 2. Coolant consumption versus film thickness.

The thermal insulation under the cited conditions is the most efficient since the total effective heat capacity of the coolant is used. Typical distribution characteristics are plotted for gas and liquid film dimensionless flow functions and reduced temperatures, as well as for concentrations of the components in the gas boundary layer.

Gaponenko, N. P. Approximation method for calculating nonstationary thermal processes in a multi-layered medium. I-FZh, v. 22, no. 6, 1972, 1126-1127.

An approximate method is suggested for calculating nonstationary thermal processes in a multi-layered wall, on one of whose surfaces a given power variation is defined. The author points out that calculations can be simplified, if it is assumed that upon power application at the wall, the following conditions apply: 1. layers situated remote from the place of power application do not affect the temperature difference between the beginning and the end of any part of multi-layered structure, other than the one under consideration; 2. a temperature increment equal to the increase of temperature difference between the beginning and the end of the considered layer takes place at every point in layers preceding the one under consideration, when the temperature drop between the beginning and the end of the considered layer has not yet reached a maximum possible value.

Differential equations are given for heat transfer processes in a particular layer, and temperature drops in the multi-layered wall are determined as a sum of drops for all layers. This method was verified experimentally by modelling transient thermal processes in an RC network, and results were found to be in good agreement. According to the author, it is thus possible to apply this method for calculating thermal processes during an arbitrary power release law in a multi-layered wall.

Rauzin, Ya. R. Certain problems of increasing structural strength of steel. MITOM, no. 6, 1972, 2-7.

The strength properties of steel are reviewed. The structural strength of steel is characterized as a complex of the properties which best characterize its work capability (the long-term strength and reliability of a part). The importance is stressed of properly selecting the criteria for evaluation of the structural strength as well as the strength parameters best suited to the service properties of machine parts and structures. Static and fatigue strength tests often do not, for example, adequately characterize the work capacity of railway rails. An important factor in the determination of the structural strength of steel is the service life or the duration of operation of a part under cyclical load from fatigue crack initiation until fracture. It is recommended that the criteria for determining the structural strength of steel adhere to the specifications of the product for which the steel is intended.

Urzhumtsev, Yu. S. Second All-Union conference on polymer mechanics. MP, no. 2, 1972, 378-380.

Eleven papers presented at the Second All-Union Conference on Polymer mechanics are summarized. The conference was held 10 - 12 November 1971 in Riga. P. M. Ogibalov, V. A. Lomakin, and G. A. Teters described the status of theoretical research on polymer deformation. They pointed out that the development of a linear phenomenological theory of thermal viscoelasticity is practically complete. A nonlinear theory synthesizing viscoelasticity and plasticity is under development. V. R. Regel et al analyzed theories of the strength of polymeric materials. They noted significant recent achievements in work on polymer fracture, and the successful development of strength and fracture theories based on the dispersion damage and microcrack accumulation in loaded materials.

The majority of the remaining papers dealt with the mechanics of polymer composites. In this category, A. K. Malmeyster traced trends in the development of an effective theory of reinforcement, leading to composites of strength and stiffness comparable to diamond-like crystal structures. V. V. Bolotin reported on bodies of revolution formed by winding and analyzed the effects of coil parameters and heat-treatment on residual structural strain. Bolotin also discussed the automation of composites manufacturing processes. In a related paper, Yu. M. Tarnopol'skiy considered the production of polymer structures from high-moduli fiber composites. New requirements were specified for improved methods of calculating and evaluating the carrying capacity of polymer composites parts. S. V. Serensen, and V. S. Strelyayev examined statistical data on the progressive fracture of glass-reinforced plastics and probability evaluations of the strength of structural elements. A. M. Skudra discussed the strength of reinforced plastics under uniaxial tension, compression, and shear. Reporting on the problems of rheology of polymer systems in fluid flow, G. V. Vinogradov, and L. A. Faytel'son recommended that research efforts be focused on the relationships between the structure of polymer composites with granular or fibrous fillers, as well as those of critical matrix parameters in the liquid state, and the performance characteristics of the polymer products. Yu. S. Urzhumtsev presented data on the development and application of diagnostics methods in the study of the deformability and fracture of polymers and polymer composites.

Zavadovskaya, Ye. K., A. I. Baranov, and V. M. Lisitsyn. Formation of intrinsic radiation defects in CaF_2, SrF_2, and BaF_2 from low temperature plasma flow. IVUZ Fiz, no. 6, 1972, 148-150.

In accordance with the view that the high radiation resistance of metal fluorides due to the high mobility of F^o atoms in the crystal lattice facilitates the "heating" of developing electron defects, it is suggested that the removal or localization of F^o atoms beyond the radiation damage boundaries, will enhance the formation of predominantly electron color centers.

CaF_2, SrF_2, and BaF_2, grown from ultrapure salts, were subjected to surface radiation in low-temperature plasma flow in an attempt to create radiation defects. The absorption spectra of the crystals are plotted in Fig. 1.

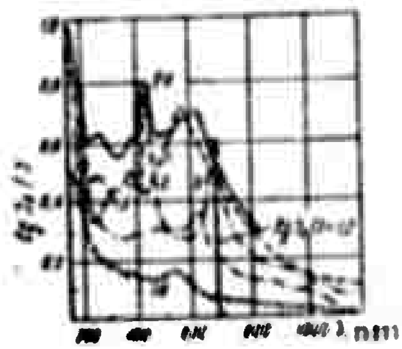

Fig. 1. Optical absorption spectra of crystals:

1- CaF_2 grown from purified natural raw material and plasma irradiated for 1 hour; 1a- CaF_2 grown from synthesized "very pure" salt and irradiated for 1 hour; 2 and 2a- SrF_2, irradiated for 1 hour and 3 hours, respectively; 3- BaF_2, irradiated for 2.5 hours.

After an initial two-hour irradiation, the BaF_2 crystal displayed a dark grey color and continuous structureless absorption in the investigated wavelength range. The crystal became transparent after annealing at 120° C. A second irradiation of BaF_2, lasting 30 minutes, resulted in a spectrum containing 504 and 680 nm absorption bands.

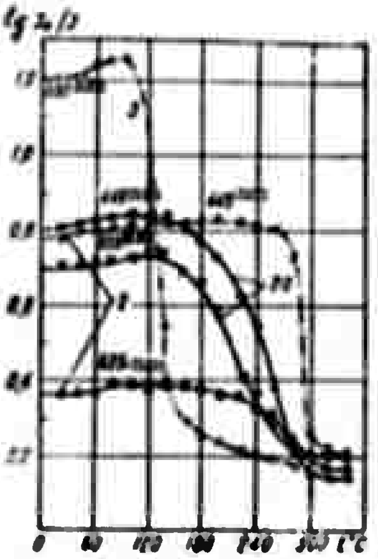

Fig. 2. Annealing kinetics of crystal optical absorption bands.

2, 2a - SrF_2, 3 - BaF_2

Fig. 2 illustrates changes of lg I_0/I as a function of annealing temperature. SrF_2 and BaF_2 crystals were annealed for 15 minutes at the given temperatures.

Crystals irradiated by low temperature plasma manifested thermoluminescence peaks which shifted into a region of higher temperatures in relation to the temperature interval of the absorption bands maximum rate of decay after annealing.

The high resistance of metal fluorides to irradiation effects is considered to be the result of the significant mobility of hole centers, of F^o atoms for example. At the same time, removal of the centers from the radiation damage zone, a decrease of mobility under low-temperature conditions, localization in the traps, and the fluoride molecule formation leads to the stabilization of the radiation defects. The defects can now be created by ionization and excitation low-energy processes.

Kornev, V. M., and V. N. Solodovnikov. Axisymmetric form of stability loss of an elastic cylindrical shell under impact. ZhPMTF, no. 2, 1972, 95-100.

A theoretical analysis is presented of the interaction between axial (u) and transverse (w) displacements of a semifinite circular cylindrical shell, pivotally supported and subjected to an axial compressive shock N. At N = const, solution of the equation of the dynamic stability loss of a thin-walled shell is sought in a first approximation in the form

$$N = N_* + \epsilon N_1 \tag{1}$$

where N_* is the critical Euler load and $\epsilon = h/R \leq 1$ (h-thickness, R-shell radius). N_* describes the boundary conditions: $N_* = N_0$ and $N_* = 0$. The solution (1) satisfies the equation of stability loss as long $\epsilon\, N_0/N_1 \geq 1$. With a series expansion and various stability loss forms W_m, the initial equation is reduced to a set of ordinary differential equations

$$\rho h \ddot{q}_m + \left\{ D\left[\left(\frac{m\pi}{l}\right)^4 + \frac{12(1-\nu^2)}{R^2h^2}\right] - N_*\left(\frac{m\pi}{l}\right)^2 + \epsilon e^*(t)\right\} q_m = f_m(t) \tag{2}$$

where ρ is the material density, D is the cylinder stiffness, ν is the Poisson ratio, m is a parameter of W_m, and $\epsilon s^*(t)$ is a small term accounting for the interaction between different values of W_m (system degrees of freedom). It is shown that the function $q_m(t)$ contains all useful information on the temporal evolution of W_m. The fastest growing W_m values are found from (2). These W_m values (deflections) of the shell increase exponentially, similarly to the W_m of a heavily loaded supported beam. Such a beam can therefore simulate a cylindrical shell with equal similarity parameters in experiments with heavy axial loads. An approximate solution of the equation of stability loss is given in the form

$$w(x,\tau) = Q(\tau)W^*(x), \quad W^*(x) = \sin \pi x / l^* \quad (0 \leqslant x \leqslant l), \quad W^*(x) = 0 \quad (x > l) \tag{3}$$

where $\tau = t - x/c$ is the real time of the N compressive load.

The interaction between u and w is illustrated in Fig. 1.

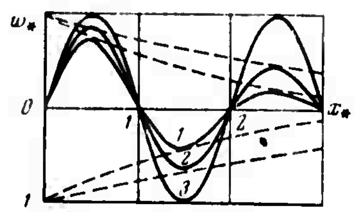

Fig. 1. Typical forms of buckling of a cylindrical shell

1- finite propagation velocity $c = c_1$ of axial perturbations, 2- $c = 2c_1$, 3- $c \to \infty$ (the fastest growing buckling form). Curve 2 describes transverse displacement.

Balter, M. A. On the mechanism of improving fatigue strength of steel by surface plastic deformation. MiTOM, no. 6, 1972, 8-11.

Changes in the fatigue strength of steel from plastic surface deformation according to the author are not explained exclusively by the values of the strength properties and residual stresses in the surface layer. The causes for retention of the strengthening action of plastic surface deformation after the removal of much of the residual stresses during cyclic overloads remain unexplained. To study the additional causes affecting fatigue strength during plastic surface deformation, research was conducted on the characteristics of amplitude-dependent internal friction, crack resistance and fine structure. Comparative fatigue tests in vacuum and a were also conducted. Results reveal that, besides the role played by macrostress and intrinsic strengthening, plastic surface deformation increases steel fatigue strength since in the surface layer where the foci of destruction originate: a) the value of local stresses decreases, b) nonuniformity of the microdistortions is equalized (in the case of a martensite structure), and c) internal friction increases. These factors increase fatigue crack resistance.

Vorob'yev, V. F., and Yu. I. Dudar'kov. Nonstationary temperature field in a flat plate with internal interaction between thermal conductivity and radiation. I-FZh, v. 22, no. 5, 1972, 899-906.

The temperature field within an infinite dielectric plate with a low reflection coefficient r is calculated with allowance for optically thick ($\tau_0 > 1$) and thin ($\tau_0 \leq 1$) radiation absorption regions. The plate is heated

by time-prescribed convective and radiative external fluxes. Double reflection and refraction of boundary surface radiation are taken into account, because their importance in radiation heat transfer increases with increases in external radiation source power and body temperature. Monochromatic radiation local spectral intensities I_λ (shown in Fig. 1) are described by an equation

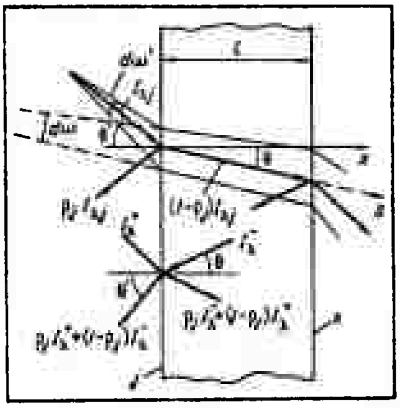

Fig. 1. Beam propagation through a flat plate.

which, together with the equation of energy transfer and its boundary condition, define the temperature field $\partial T/\partial t$, where T is temperature and t time. Allowance is made for the radiation law of refraction and natural polarization. The plate net radiation flux q_r is calculated for the spectral absorption regions with $\tau_0 > 1$ and $\tau_0 < 1$. The problem is then solved by the method of finite differences using step approximation of the $\rho(\theta')$ function, where ρ is the reflection coefficient. The plate temperature T is computed for a given radiation flux from the x = 0 surface with a $\overline{T}_j(t)$ gas temperature, and either a convective flux in enthalpic presentation or a $q_j(t)$ flux. The convective thermal flux on an $x=\ell$ surface is also given. Calculated temperature vs. time curves are shown for silicate glass and quartz plates. The glass plate curves were compared with curves calculated earlier without asymptotic presentation of q_r and allowance for the small ρ value. The two sets

of curves coincide within ~5%. For the quartz plate, the calculated T(t) curves at both surfaces of a partly transparent plate deviated from the corresponding T(t) curves of an opaque plate(emissivity $\epsilon = 0.91$) at $T > 300^{\circ}$ C. The discrepancy between the two sets of curves increased to a maximum at peak T due to the thermal energy emission from quartz. This effect was less pronounced in the silicate glass.

Goloskokov, Ye. G., and V. P. Ol'shanskiy. Elastic shock on a tri-layer plate in the presence of concentrated masses and nonlinear supports. MTT, no. 3, 1972, 111-116.

The dynamics of elastic impact on a tri-layered isotropic plate of arbitrary thickness are described. A rectangular plate is examined, simply supported at the edges with resilient supports and concentrated masses. The elastic impact is described by the set of integral equations

$$W(x, y, t) = F(W_1, \ldots, W_{n_1}; \ddot{W}_{n_1+1}, \ldots, \ddot{W}_{n_1+n_2}; P; x, y, t) \tag{1}$$

$$vt - M^{-1} \int_0^t dt_1 \int_0^{t_1} P\, dt = W(x_0, y_0, t) + k_1 P^{\gamma} + k_{20} P \tag{2}$$

$$W_s = \int_0^t dt_1 \int_0^{t_1} \ddot{W}_s\, dt \quad (s - n_1 = 1, 2, \ldots, n_2) \tag{3}$$

where W is the mean transverse deformation; W_1---W_{n1} are the local transverse deformations at the resilient support points; $\ddot{W}_{n1+1}$-$\ddot{W}_{n1+2}$ (= $\ddot{W}_s$) are the accelerations due to concentrated mass M_s; P is the impact

stress; v and M are the velocity and mass of the impacting body, W (x_0, y_0, t) is the local deformation at the point of impact, and $k_1 P^q = a_c$ is the convergence of the colliding bodies. A numerical solution of equations (2)-(3) by step approximation of P, $\ddot{W}_s$, and W_i is obtained, assuming that the resilient supports are spaced so that the craters of local deformations are not superimposed.

Examples of calculations of the direct central impact of a steel ball on a stiffened tri-layer plate are shown. In the first example, a symmetric 3x2 m plate, made of EK filler sandwiched between two 0.3 cm thick steel sheets, is supported at two points by equally stiffened resilient mountings ($C_{21} = C_{22}$)(Fig. 1).

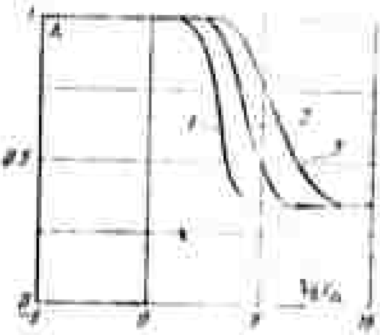

Fig. 1. Ratio λ of maximum deflections, with and without additional supports, versus log C_{2i} : 1- linear support, 2 and 3- quadratic and cubic nonlinear supports.

In the second example, an asymmetric plate made of an unspecified material sandwiched between steel and aluminum sheets is not supported by additional mountings, but does contain a central concentrated mass M_1 (Fig. 2).

Fig. 2. Maximum impact stress P versus β = M_1/M: 1- impacted steel surface, 2- impacted aluminum surface.

At increased M_1, the maximum impact stress increases faster on the steel surface than on the aluminum surface.

Lomakin, Ye. V., V. G. Lyuttsau, A. F. Mel'shanov, and Yu. N. Rabotnov. Propagation of longitudinal elastoplastic waves in low carbon steels. MTT, no. 2, 1972, 180-185.

Results are presented of an experimental investigation of elastoplastic wave propagation in low-carbon steel rods with yield retardation. It was established that the elastic wave front is followed by an elastic unloading front, behind which deformation remains practically constant until the arrival of the plastic waves. The stress corresponding to the region of constant deformation is called the lower yield limit; it is considerably higher than the lowest static yield point. X-ray and metallographic research suggests that the mechanism of plastic deformation is different for dynamic and static tests.

A model of an elastoplastic medium with yield retardation based on the theory of Taylor-Rakhmatullin of a single curve of dynamic deformation independent of velocity was proposed earlier by Rabotnov (PMTF, no. 3, 1968). The experimental results reveal a propagation pattern of longitudinal elastoplastic waves in rods which quantitatively confirms the Rabotnov model. After impact, a forward elastic wave propagates along the rod. At the moment of exhaustion of the yield retardation an elastic unloading wave propagates along the rod at the end receiving the impact. The unloading in this wave occurs in accordance with an elastic law, and the stress can be determined on the basis of a known deformation value. A region of deformation and stress values which are nearly constant is behind the unloading wave. When yield begins, a wave also propagates along the rod, at the front of which plastic deformation begins to increase rapidly. Unloading proceeds very rapidly (about 2 microseconds). The phenomenon of unloading during a specific time can be explained by the effect of tridimensionality of the stressed state, as well as by the influence of the rate of deformation upon the flow stress in the region immediately adjacent to the impacted end.

B. Recent Selections

1. Crack Propagation

Akimbekov, Kh., V. S. Kuksenko, S. Nizamidinov, A. I. Slutsker, and A. A. Yastrebinskiy. Ultraviolet irradiation acceleration of submicroscopic crack formation in loaded polymers. FTT, no. 9, 1972, 2708-2713.

Andreykiv, A. Ye., V. V. Panasyuk, and M. M. Stadnik. Brittle fracture of prismatic beams weakened by internal circular cracks. Problemy prochnosti, no. 10, 1972, 37-41.

Fibers with visual capabilities. [Fiber optics wear test devices]. Znaniye-sila, no. 8, 1972, 6.

Gorshkov, A. I., B. A. Matyushkin, V. N. Meshcheryakov, and M. Kh. Shorshorov. Effect of hydrogen on kinetic growth of cold cracks in titanium from welding. FiKhOM, no. 5, 1972, 140-143.

Kareta, N. L., and V. N. Sladkova. Ductile slip in the terminus of an iron crystal crack. Problemy prochnosti, no. 9, 1972, 113-116.

Kirilyuk, L. V., and M. Sh. Gol'dberg. Study of dislocation crack formation in ion crystals. IN: Sbornik. Dielektriki, no. 1, 1971, 21-24. (RZhF, 7/72, no. 7Ye683)

Kit, G. S. Problems of thermal strength of bodies with cracks. VAN UkrSSR, no. 4, 1972, 22-28. (RZhMekh, 9/72, no. 9V452)

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$$\frac{R}{l} = \frac{AI}{W_{in.}}, \tag{1}$$

where

$$A = \frac{\frac{3}{2}\left(\frac{1}{x_i} + 1\right)kT + e\varepsilon_i}{e\mu_e}, \tag{2}$$

in which x_i is ionization level of the plasma. The magnitude of A is found from experimental data to be approximately constant, under given test conditions, from initial breakdown until the current pulse peak. Further treatment is then given in terms of A, which the authors define as the "spark constant." Since similarity criteria are shown to be met, the π theorem may be used to derive equations for i, R, and P_a all in terms of three dimensionless constants, which permit a quantitative evaluation to be made of A - i.e. the degree of plasma ionization, its temperature, and the mobility and potential of ionized atoms.

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SOURCE ABBREVIATIONS

AiT	-	Avtomatika i telemekhanika
APP	-	Acta physica polonica
DAN ArmSSR	-	Akademiya nauk Armyanskoy SSR. Doklady
DAN AzSSR	-	Akademiya nauk Azerbaydzhanskoy SSR. Doklady
DAN BSSR	-	Akademiya nauk Belorusskoy SSR. Doklady
DAN SSSR	-	Akademiya nauk SSSR. Doklady
DAN TadSSR	-	Akademiya nauk Tadzhikskoy SSR. Doklady
DAN UkrSSR	-	Akademiya nauk Ukrainskoy SSR. Dopovidi
DAN UzbSSR	-	Akademiya nauk Uzbekskoy SSR. Doklady
DBAN	-	Bulgarska akademiya na naukite. Doklady
EOM	-	Elektronnaya obrabotka materialov
FAiO	-	Akademiya nauk SSSR. Izvestiya. Fizika atmosfery i okeana
FGiV	-	Fizika goreniya i vzryva
FiKhOM	-	Fizika i khimiya obrabotka materialov
F-KhMM	-	Fiziko-khimicheskaya mekhanika materialov
FMiM	-	Fizika metallov i metallovedeniye
FTP	-	Fizika i tekhnika poluprovodnikov
FTT	-	Fizika tverdogo tela
FZh	-	Fiziologicheskiy zhurnal
GiA	-	Geomagnetizm i aeronomiya
GiK	-	Geodeziya i kartografiya
IAN Arm	-	Akademiya nauk Armyanskoy SSR. Izvestiya. Fizika
IAN Az	-	Akademiya nauk Azerbaydzhanskoy SSR. Izvestiya. Seriya fiziko-tekhnicheskikh i matematicheskikh nauk

IAN B	-	Akademiya nauk Belorusskoy SSR. Izvestiya. Seriya fiziko-matematicheskikh nauk
IAN Biol	-	Akademiya nauk SSSR. Izvestiya. Seriya biologicheskaya
IAN Energ	-	Akademiya nauk SSSR. Izvestiya. Energetika i transport
IAN Est	-	Akademiya nauk Estonskoy SSR. Izvestiya. Fizika matematika
IAN Fiz	-	Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya
IAN Fizika zemli	-	Akademiya nauk SSSR. Izvestiya. Fizika zemli
IAN Kh	-	Akademiya nauk SSSR. Izvestiya. Seriya khimicheskaya
IAN Lat	-	Akademiya nauk Latviyskoy SSR. Izvestiya
IAN Met	-	Akademiya nauk SSSR. Izvestiya. Metally
IAN Mold	-	Akademiya nauk Moldavskoy SSR. Izvestiya. Seriya fiziko-tekhnicheskikh i matematicheskikh nauk
IAN SO SSSR	-	Akademiya nauk SSSR. Sibirskoye otdeleniye. Izvestiya
IAN Tadzh	-	Akademiya nauk Tadzhiksoy SSR. Izvestiya. Otdeleniye fiziko-matematicheskikh i geologo-khimicheskikh nauk
IAN TK	-	Akademiya nauk SSSR. Izvestiya. Tekhni-cheskaya kibernetika
IAN Turk	-	Akademiya nauk Turkmenskoy SSR. Izvestiya. Seriya fiziko-tekhnicheskikh, khimicheskikh, i geologicheskikh nauk
IAN Uzb	-	Akademiya nauk Uzbekskoy SSR. Izvestiya. Seriya fiziko-matematicheskikh nauk
IBAN	-	Bulgarska akademiya na naukite. Fizicheski institut. Izvestiya na fizicheskaya institut s ANEB
I-FZh	-	Inzhenerno-fizicheskiy zhurnal

IiR	-	Izobretatel' i ratsionalizator
ILEI	-	Leningradskiy elektrotekhnicheskiy institut. Izvestiya
IT	-	Izmeritel'naya tekhnika
IVUZ Avia	-	Izvestiya vysshikh uchebnykh zavedeniy. Aviatsionnaya tekhnika
IVUZ Cher	-	Izvestiya vysshikh uchebnykh zavedeniy. Chernaya metallurgiya
IVUZ Energ	-	Izvestiya vysshikh uchebnykh zavedeniy. Energetika
IVUZ Fiz	-	Izvestiya vysshikh uchebnykh zavedeniy. Fizika
IVUZ Geod	-	Izvestiya vysshikh uchebnykh zavedeniy. Geodeziya i aerofotos"yemka
IVUZ Geol	-	Izvestiya vysshikh uchebnykh zavedeniy. Geologiya i razvedka
IVUZ Gorn	-	Izvestiya vysshikh uchebnykh zavedeniy. Gornyy zhurnal
IVUZ Mash	-	Izvestiya vysshikh uchebnykh zavedeniy. Mashinostroyeniye
IVUZ Priboro	-	Izvestiya vysshikh uchebnykh zavedeniy. Priborostroyeniye
IVUZ Radioelektr	-	Izvestiya vysshikh uchebnykh zavedeniy. Radioelektronika
IVUZ Radiofiz	-	Izvestiya vysshikh uchebnykh zavedeniy. Radiofizika
IVUZ Stroi	-	Izvestiya vysshikh uchebnykh zavedeniy. Stroitel'stvo i arkhitektura
KhVE	-	Khimiya vysokikh energiy
KiK	-	Kinetika i kataliz
KL	-	Knizhnaya letopis'
Kristall	-	Kristallografiya
KSpF	-	Kratkiye soobshcheniya po fizike

LZhS	-	Letopis' zhurnal'nykh statey
MiTOM	-	Metallovedeniye i termicheskaya obrabotka materialov
MP	-	Mekhanika polimerov
MTT	-	Akademiya nauk SSSR. Izvestiya. Mekhanika tverdogo tela
MZhiG	-	Akademiya nauk SSSR. Izvestiya. Mekhanika zhidkosti i gaza
NK	-	Novyye knigi
NM	-	Akademiya nauk SSSR. Izvestiya. Neorganicheskiye materialy
NTO SSSR	-	Nauchno-tekhnicheskiye obshchestva SSSR
OiS	-	Optika i spektroskopiya
OMP	-	Optiko-mekhanicheskaya promyshlennost'
Otkr izobr	-	Otkrytiya, izobreteniya, promyshlennyye obraztsy, tovarnyye znaki
PF	-	Postepy fizyki
Phys abs	-	Physics abstracts
PM	-	Prikladnaya mekhanika
PMM	-	Prikladnaya matematika i mekhanika
PSS	-	Physica status solidi
PSU	-	Pribory i sistemy upravleniya
PTE	-	Pribory i tekhnika eksperimenta
Radiotekh	-	Radiotekhnika
RiE	-	Radiotekhnika i elektronika
RZhAvtom	-	Referativnyy zhurnal. Avtomatika, telemekhanika i vychislitel'naya tekhnika
RZhElektr	-	Referativnyy zhurnal. Elektronika i yeye primeneniye

RZhF	-	Referativnyy zhurnal. Fizika
RZhFoto	-	Referativnyy zhurnal. Fotokinotekhnika
RZhGeod	-	Referativnyy zhurnal. Geodeziya i aeros"-yemka
RZhGeofiz	-	Referativnyy zhurnal. Geofizika
RZhInf	-	Referativnyy zhurnal. Informatics
RZhKh	-	Referativnyy zhurnal. Khimiya
RZhMekh	-	Referativnyy zhurnal. Mekhanika
RZhMetrolog	-	Referativnyy zhurnal. Metrologiya i izmeritel'naya tekhnika
RZhRadiot	-	Referativnyy zhurnal. Radiotekhnika
SovSciRev	-	Soviet science review
TiEKh	-	Teoreticheskaya i eksperimental'naya khimiya
TKiT	-	Tekhnika kino i televideniya
TMF	-	Teoreticheskaya i matematicheskaya fizika
TVT	-	Teplofizika vysokikh temperatur
UFN	-	Uspekhi fizicheskikh nauk
UFZh	-	Ukrainskiy fizicheskiy zhurnal
UMS	-	Ustalost' metallov i splavov
UNF	-	Uspekhi nauchnoy fotografii
VAN	-	Akademiya nauk SSSR. Vestnik
VAN BSSR	-	Akademiya nauk Belorusskoy SSR. Vestnik
VAN KazSSR	-	Akademiya nauk Kazakhskoy SSR. Vestnik
VBU	-	Belorusskiy universitet. Vestnik
VNDKh SSSR	-	VNDKh SSSR. Informatsionnyy byulleten'
VLU	-	Leningradskiy universitet. Vestnik. Fizika, khimiya
VMU	-	Moskovskiy universitet. Vestnik. Seriya fizika, astronomiya

ZhETF	-	Zhurnal eksperimental'noy i teoreticheskoy fiziki
ZhETF P	-	Pis'ma v Zhurnal eksperimental'noy i teoreticheskoy fiziki
ZhFKh	-	Zhurnal fizicheskoy khimii
ZhNiPFiK	-	Zhurnal nauchnoy i prikladnoy fotografii i kinematografii
ZhNKh	-	Zhurnal neorganicheskoy khimii
ZhPK	-	Zhurnal prikladnoy khimii
ZhPMTF	-	Zhurnal prikladnoy mekhaniki i tekhnicheskoy fiziki
ZhPS	-	Zhurnal prikladnoy spektroskopii
ZhTF	-	Zhurnal tekhnicheskoy fiziki
ZhVMMF	-	Zhurnal vychislitel'noy matematiki i matematicheskoy fiziki
ZL	-	Zavodskaya laboratoriya

9. AUTHOR INDEX

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